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MIL-HDBK-1012/3
31 MAY 1996

MILITARY HANDBOOK

TELECOMMUNICATIONS PREMISES DISTRIBUTION
PLANNING, DESIGN, AND ESTIMATING

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ABSTRACT

This handbook provides criteria for the planning, design, and estimating of premises distribution systems required for military construction (MILCON) projects.

FOREWORD

This handbook has been developed from an evaluation of facilities at DOD establishments, from surveys of the availability of new material and construction methods, and from selection of the best design practices of the Naval Facilities Engineering Command (NAVFACENGCOM), Army Corps of Engineers, other Government agencies, and the private sector. This handbook was prepared using, to the maximum extent feasible, national professional society, association, and institute standards. Do not deviate from this criteria in the planning, engineering, design, and construction of DOD facilities without prior approval of the respective component office of responsibility--U.S. Army, HQ USACE/CEMP-E or USAISEC CONUS or the appropriate USAISEC geographical office, U.S. Navy, NAVFACENGCOM Code 15C.

The following applies to Army projects: The cost estimating guidance in this handbook will not be used. The Information Systems Cost Estimator (ISCE) for Windows shall be used to establish cost estimates for all Army projects. The use of a Registered Communications Distribution Designer (RCDD) is not mandatory. For all Army Medical projects, any further deviation from this criteria must be approved by the HQ USACE Medical Facilities Design Office - CEMP-EM.

The following applies to Navy projects: The outside plant backbone telecommunications cabling should be single mode fiber optic media installed in a modified star architecture to allow migration to asynchronous transmission mode (ATM) architecture without media replacement. The backbone cabling shall also comply with Navy Base Communications Standards prepared by the Navy Computer and Telecommunications Command. Navy designs should be prepared and approved by a registered communication distribution designer (RCDD). Navy planners, engineers, designers, telecommunications specialists, and base communications officers should use the Navy telecommunications software cost estimating program TELECOM which is provided on the Construction Criteria Base (CCB). A partial listing of commercial and Government standards, that addresses telecommunications design and installation practices, is provided in Appendix A. This list should be reviewed jointly by the major claimant and the RCDD to confirm the adequacy of the commercial standards to meet the telecommunications requirements of the facility.

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Change 1, 30 November 1996

FOREWORD (Continued)

Recommendations for improvement are encouraged. Submit recommendations using the DD Form 1426 provided inside the back cover to the respective component office of responsibility. Approved recommendations will be forwarded to Commander, Naval Facilities Engineering Command (NAVFACENGCOM), Code 15C, 1510 Gilbert Street, Norfolk, VA 23511-2699; telephone commercial (757) 322-4208, facsimile machine (757) 322-4416.

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MILITARY HANDBOOK

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CONTENTS

Section		Page
1	TELECOMMUNICATIONS PLANNING AND DESIGN	
1.1	Overview	1
1.1.1	Responsibilities	1
1.1.2	Scope	1
1.1.3	Objective	3
1.2	Design	3
1.2.1	Methodology	5
1.2.2	Approach	7
1.3	User Workstation Requirements	7
1.3.1	Workstation Capabilities	7
1.3.2	Cables to the Workstation	7
1.3.2.1	Unshielded Twisted Pair (UTP)	7
1.3.2.2	Fiber Optic Cable	8
1.3.2.3	Screened UTP	8a
1.3.2.4	Coaxial Cable	8a
1.3.2.5	Shielded 150 Ohm Cable	13
1.3.3	Wall-Mounted Outlets and Conduit	13
1.4	Horizontal Cable Requirements	13
1.4.1	Building Usage	13
1.4.1.1	Administrative	14
1.4.1.2	Headquarters	15
1.4.1.3	Command and Control Center	16
1.4.1.4	Training	16
1.4.1.5	Technical or Laboratory	17
1.4.1.6	Hospital	17
1.4.1.7	Bachelor Quarters	18
1.4.1.8	Single Family Housing	20
1.4.1.9	Guard Shack	22
1.4.1.10	Warehouse	22
1.4.1.11	Miscellaneous	23
1.5	Horizontal Pathways	23
1.5.1	Types of Horizontal Pathways	24
1.5.1.1	Underfloor Duct	24
1.5.1.2	Ceiling Distribution System	32
1.5.1.3	Conduit Systems	34
1.5.1.4	Access Floors	37
1.5.1.5	Tray and Ladder Systems	38
1.6	Telecommunications Closets	38
1.6.1	Telecommunications Closet Requirements	39
1.7	Horizontal Cable Installation and Termination	41
1.7.1	Installation	42
1.7.2	Termination	44
1.7.2.1	CAT 3 and 5 Terminations	44
1.7.2.2	Fiber Optic Terminations	46
1.7.3	Testing	46

	<u>Page</u>
1.7.3.1 CAT 3 and 5 Testing	46
1.7.3.2 Fiber Optic Testing	46
1.8 Backbone Design	47
1.8.1 Voice Backbone Cable Requirements	47
1.8.2 Data Backbone Cable Requirements	48
1.8.3 Vertical Backbone Physical Support Structure	49
1.8.4 Campus Backbone Physical Support Structure ..	52
1.8.4.1 Direct Burial	53
1.8.4.2 Underground	54
1.8.4.3 Tunnel	57
1.8.4.4 Aerial	59
1.9 Equipment Room and Entrance Facility	61
1.9.1 Equipment Room Location	62
1.9.2 Equipment Room Supplementary Design Considerations	65
1.9.2.1 Access	65
1.9.2.2 Lighting	65
1.9.2.3 Fire and Security	66
1.9.3 Equipment Room Environmental Considerations	66
1.9.4 Equipment Room Electrical Considerations	66
1.9.5 Equipment Room Structural Considerations	67
1.9.5.1 Flooring	67
1.9.5.2 Walls	68
1.9.5.3 Cable Management Support	68
1.10 Telecommunications Grounding and Protection	68

APPENDIX

APPENDIX A	Do's and Don'ts of Category (CAT) 5 Cabling	80
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FIGURES

Figure	1	DD Form 1391 Planning	2
	2	Building Distribution Scheme	6
	3	Standard Workstation	9
	4	Telecommunications Outlet	10
	5	Modular Furniture Faceplate	11
	6	Duplex Fiber Optic 568SC Connector	12
	7	BQ Floor Plan	19
	8	Single Family Housing Floor Plan	21
	9	Single-Level Underfloor Duct	25
	10	Two-Level Underfloor Duct	26

11	Flush Duct Underfloor System	27
12	Telecommunications Closet	40
13	Horizontal Distances	43
14	Cable Tie Length	45
15	Modular Plug Pin-Out	50
16	Tree Topology	51
17	Entrance Duct Drainage	58
18	Equipment Room	63
BIBLIOGRAPHY		71
REFERENCES		82
GLOSSARY		87

Section 1: TELECOMMUNICATIONS PLANNING AND DESIGN

1.1 Overview

1.1.1 Responsibilities. The DOD construction agency responsible for the construction of facilities is either the United States Army Corps of Engineers or NAVFACENGCOM, as assigned within the respective geographic areas by the Office of the Secretary of Defense. DOD directives 5136.10, Defense Medical Support Activity and 6015.16, DOD Policies for Planning Fixed Military Health Facilities provide additional information. Telecommunications support for MILCON projects is outlined in MIL-HDBK-1190, Facility Planning and Design Guide. This handbook addresses only the requirements for telecommunications pathways and cabling necessary to support voice, data, and video systems permanently installed in the facility. Other systems, such as security, fire alarms, and environmental monitoring, which are not addressed here, also have similar cabling requirements.

The designer should consult with the electrical and security designers to consider joint use pathways, where economically feasible. In general the construction agency is responsible for providing inside and outside cabling and support structures (pathways) necessary to provide a complete and usable telecommunications distribution system. The handbook contains planning, design, and installation criteria. Parametric cost estimating software is provided on the CCB system optional cost databases identified as TELECOM. This software currently provides cost data for the interior building cabling, backbone cabling, and pathways to the closest maintenance hole connection. This handbook does not address an evaluation or expansion of the outside plant or central switching and routing systems.

1.1.2 Scope. As shown in the flowchart in Figure 1, given only the square footage per floor of the proposed facility and its function or functional areas, the estimator should be able to quantify and estimate the cost of the following telecommunications cabling items:

a) The maximum number of generic workstations per floor which the facility will support;

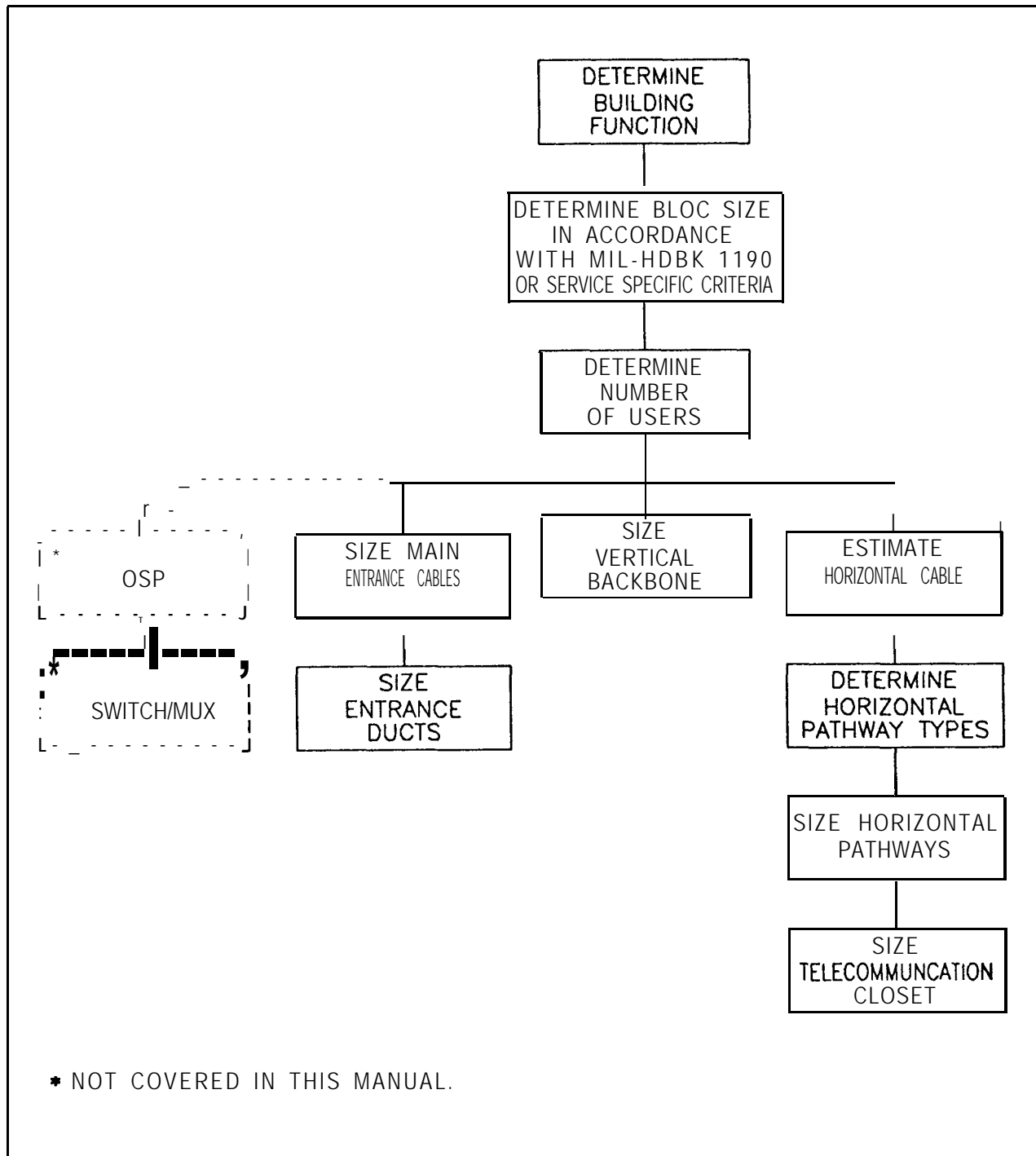


Figure 1
DD Form 1391 Planning

b) The amount of copper and/or fiber optic horizontal distribution cable required to serve the workstations from the nearest telecommunications closet;

c) The type and size of the horizontal pathways, given the type of floor and ceiling construction;

d) The number of telecommunications closets and their sizes;

e) The size of the copper (voice) and fiber optic local area network (LAN) vertical distribution cables serving each floor;

f) The number of vertical ducts or sleeves serving each floor;

g) The size of the fiber optic and/or copper entrance cables; and

h) The size of the cable entrance facility, including the service entrance.

Note: Without the actual construction plans it will not be possible to determine the exact locations of the telecommunications closets but given the square footage of usable floor space the number and size of the closets can be estimated.

1.1.3 Objective. The objective of the planning evolution is the development of an input to the telecommunications portion of the DD Form 1391. This baseline figure is a composite of the costs projected to engineer, furnish, and install requisite horizontal cabling systems to support the anticipated user population over the expected life cycles of both the voice and data systems and vertical backbone cabling and pathways designed to support upgrades in the horizontal system for the life of the structure. Base telecommunications support is predicated upon the availability of the existing telephone, data, and distribution systems to provide the necessary connectivity and system access to the increased user population. The assessment of plant-in-place outside plant, switching and routing systems, and the engineering required to modify or expand them, is not addressed in this handbook.

1.2 Design. The planning, design and installation of a building or campus telecommunications infrastructure requires the selection of appropriate hardware, cable and support structures, and decisions regarding types of pathways and topologies. The Building Industry Consultant Services International (BICSI)

provides testing and registration services resulting in the designation of the registered communications distribution designer (RCDD). The RCDD designation is held by both Government and commercial telecommunications designers and should become a requirement for those preparing and reviewing architectural plans for telecommunications installations. It is incumbent upon the RCDD assigned to the project to determine the requirements and formulate a design through an organized decision making process. These decisions will form the primary design elements necessary to interface the building or campus tenants (generally referred to as the local users) to the serving local and wide area networks (LANs/WANs) and telecommunications systems, which the user must access to meet mission performance objectives. The primary design elements to be assessed when developing a building or campus telecommunications infrastructure include: workstation requirements and locations; type and quantity of horizontal cable distribution; location and size of telecommunications closets; type and size of vertical cable distribution and supporting pathways; building entrance or point of presence (POP); and inter-building (outside plant) distribution. Each of these design elements forms an integral part of the overall telecommunications distribution system. Figure 2 illustrates a typical building distribution scheme. It is the responsibility of the design agency or team to integrate each element into a comprehensive distribution design which will meet the telecommunications connectivity requirements consistent with the functionality of the building and its tenants. The design objective is to ensure that the building and campus cable pathways will be capable of supporting cabling requirements for the useful life of the building, 50 years. The building's horizontal cable plant is expected to accommodate telecommunication requirements for a minimum period of 10 years. This section defines the telecommunications requirements for various types of buildings, introduces applicable standards, and provides rationale for the optional decisions that may be made to alter the default conditions in the estimating software. Commercial standards have been used in determining these requirements. Electronic Industries Association (EIA)/TIA 568, Commercial Building Telecommunications Cabling Standard and TIA 569, Commercial Building Standard for Telecommunications Pathways and Spaces and NFPA 70, National Electrical Code provide the majority of the direction. The RCDD must be familiar with these references. This section lends itself equally to new construction and renovation projects. In the case of renovation, the RCDD must be conscious of existing systems which may be comprised of older distribution materials no longer recommended by commercial standards. For instance, a building wired with 50 ohm coaxial cable for LAN operations may be rewired with CAT 5 unshielded twisted pair (UTP) to support future requirements and

conform to EIA TIA 568 recommendations. However, the RCDD should be aware that should existing workstations remain in the building, they will require balanced/unbalanced (BALUN) impedance matching devices to match the unbalanced coaxial cable network interface card (NIC) to the 100 ohm balanced UTP cable. There may also be instances where advanced technology, such as wireless LANs, may provide a simpler or interim solution to engineering problem associated with building refurbishment. It is recommended that the RCDD research these alternative solutions prior to deciding which telecommunications system is best suited for the project.

1.2.1 Methodology. The communications cabling that supports voice, data, and video distribution throughout the building, and in some cases interfaces with a campus backbone, is an integral part of the design and construction process. The proper estimate of construction costs and allocation of floor and ceiling space depends upon the ability of the RCDD to determine the answers to typical questions such as:

- a) How many voice and data outlets will be required in each area?
- b) How will users in open bay areas be served?
- c) How many cables of each type will be run to each outlet?
- d) What type of horizontal distribution pathways should be used? (Should cables be run in the floor or in the ceiling?)
- e) Are cable runs too close to sources of electromagnetic interference (EMI)?
- f) Where conduit is used, what size should it be?
- g) Where should the telecommunications closets be located and what size should they be?
- h) What is the size and quantity of vertical and entrance ducts?

DCO = DIAL CONTROL OFFICE
 DSS = DIGITAL SWITCHED SYSTEM (VOICE)
 ICC = INTERMEDIATE CROSS CONNECT
 LAN = LOCAL AREA NETWORK (DATA)
 LEC = LOCAL EXCHANGE CARRIER
 MCC = MAIN CROSS CONNECT
 MDF = MAIN DISTRIBUTION FRAME
 MPOP = MINIMUM POINT OF PRESENCE
 TC = TELECOMMUNICATION CLOSET
 WAN = WIDE AREA NETWORK

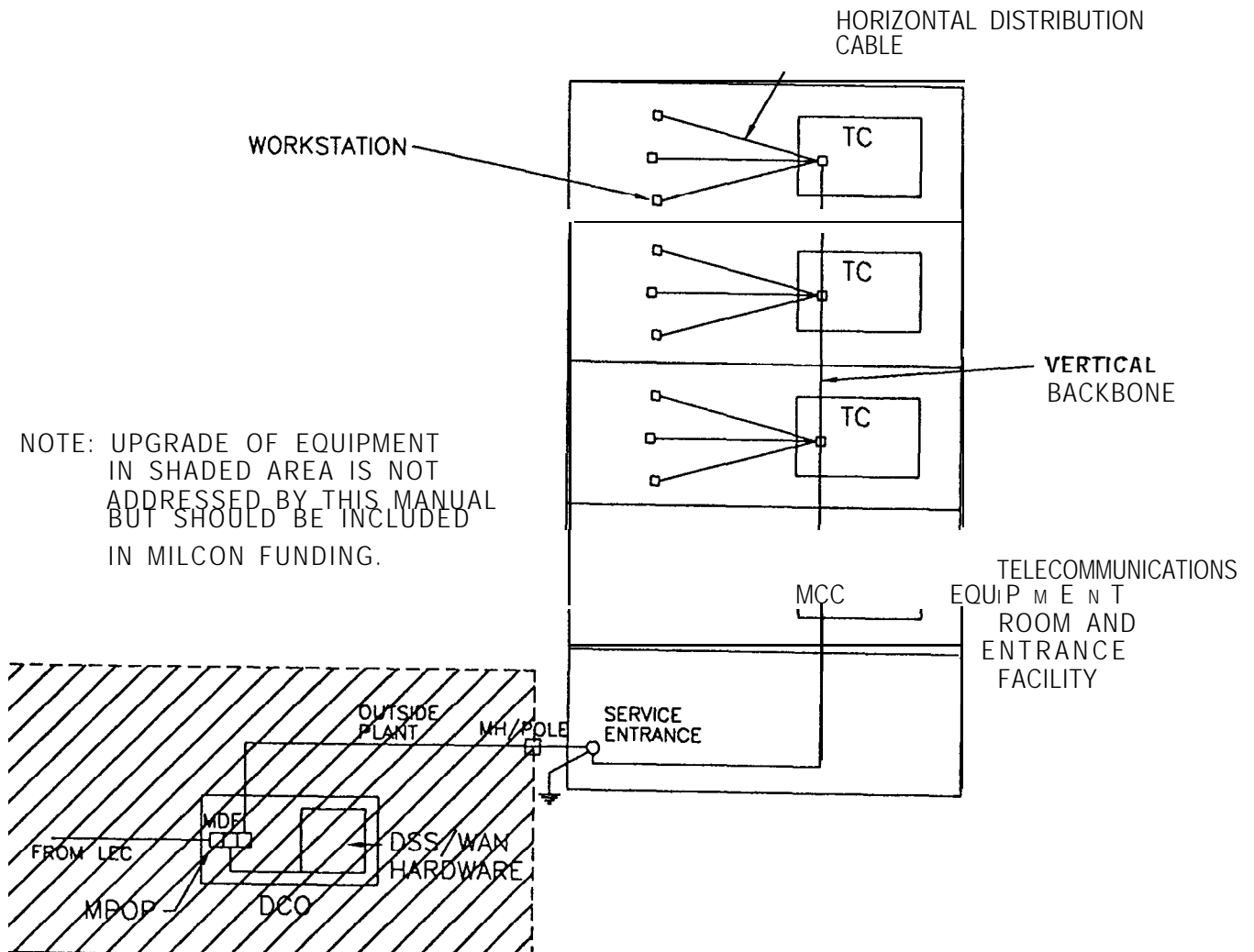


Figure 2
 Building Distribution Scheme

1.2.2 Approach. The communications design process must begin with an analysis of the user workstations. Their number and configurations determine the amount and type of horizontal cables to be pulled, either through embedded floor ducts or through the ceiling, from the workstation outlets to the serving telecommunications closets. This information will also be used to determine the locations and sizes of the telecommunications closets and the composition and size of the backbone and entrance facilities.

1.3 User Workstation Requirements

1.3.1 Workstation Capabilities. A workstation is defined as the place, such as a desk or fixed position, where an employee performs his or her daily duties. It consists of a voice instrument and a personal computer (PC) or terminal, as shown in Figure 3. Workstations, whether within a walled office or an open bay area, will be provided with voice access to the resident network via a unique telephone number. This is referred to as the "single line concept." Workstations will also be provided with connectivity to the LAN for access to the applications, utilities, and files resident on the network server. It is the responsibility of the RCDD to ensure that cabling and support structures required to connect the workstation via intermediate telecommunications closets to the equipment room and building entrance facility are in accordance with applicable standards.

1.3.2 Cables to the Workstation. The voice and data station cables leaving the workstation are connected to the building horizontal cabling system by means of a faceplate configured with the appropriate voice and data modular inserts. A typical faceplate configuration is shown in Figure 4. The faceplate should be flush mounted on the wall rather than surface mounted wherever possible. Faceplates specifically designed for installation in the baseplate of modular furniture are available for open bay areas. See Figure 5.

1.3.2.1 Unshielded Twisted Pair (UTP). Four pair, 24 AWG, 100 ohm, UTP is the preferred media for bringing voice and data to the workstation. The two categories of UTP cable approved for general use are categories (CAT's) 3 and 5. CAT 3 cable is manufactured to specifications that will support voice and data at operating rates not to exceed 16 MHZ. CAT 3 components are tested to 16 MHZ but are

not recommended for operations above 10 MHz because of their susceptibility to wide variations in attenuation as a result of variations in temperature. To support rapidly rising data rates over a 10-year period, the use of CAT 3 cable should be restricted to voice or alarm systems. CAT 5 cable may also be employed for voice circuits where specified by the military department (MILDEP) or to avoid excessive levels of cross talk. UTP is not specified as the transmission media for data circuits which exceed a transmission rate of 100 MHz. However, UTP cables are being researched for use at data rates in excess of 100 MHz for applications such as the transmission of asynchronous transfer mode (ATM). Additionally, the National Electrical Manufacturers' Association (NEMA) is developing a specification, WC-66, for a high frequency low loss, extended frequency 100 ohm screened or shielded cable for operations up to 300 MHz.

1.3.2.2 Fiber Optic Cable. Fiber optic media must comply with EIA/TIA 568, EIA TSB-72, Centralized Optical Fiber Cabling Guidelines, and Article 770 of NFPA 70. Fiber optic media in vertical pathways must conform to UL 1666, Flame Propagation Height of Electrical and Optical Fiber Cables Installed Vertically in Shafts. Fiber optic media in air handling plenums must pass NFPA 262, Fire and Smoke Characteristics of Wires and Cables. Multimode, 62.5/125 micron, tight buffered, tight tube, fiber distributed digital interface (FDDI) grade fiber optic cable should be installed in the vertical backbone to support data systems and may be substituted for the CAT 5 horizontal data cable when required by user terminal equipment. Installation and termination of fiber optic cable is comparable to that of CAT 5 in cost and level of effort; however, the cost of the electronics necessary for electro-optic conversion results in a somewhat higher total cost for the fiber optic installation. This cost is decreasing. When employed, the fiber optic jack will be a duplex device housing two unidirectional fiber optic terminations. The duplex 568SC connector specified in EIA/TIA 568 is shown in Figure 6. Activities currently employing ST connectors may continue to do so.

Single-mode fiber may be required for inter-building backbone applications and may be specified by the major claimant for vertical backbone support of high data rates.

1.3.2.3 Screened UTP. CAT 5 100 ohm UTP is available with a grounded screen for additional EMI containment or rejection. Unique eight-pin modular plugs and jacks are required to provide a path for the ground circuit between the workstation and the network equipment.

1.3.2.4 Coaxial Cable. Fifty ohm coaxial cable is not normally recommended for new construction, but may exist in refurbished buildings where existing Ethernet electronics are to remain. If existing 50 ohm coaxial systems are to be modified, the RCDD should consult the original equipment manufacturer (OEM) for: recommended maximum cable lengths, approximately 200 m (600 ft.); minimum distances between drops, approximately 2.5 m (8 ft.) and the maximum number of drops per run (approximately 28) prior to modifying any coaxial runs. Connection of equipment designed for unbalanced coaxial distribution cable to a balanced UTP network requires the use of a BALUN device.

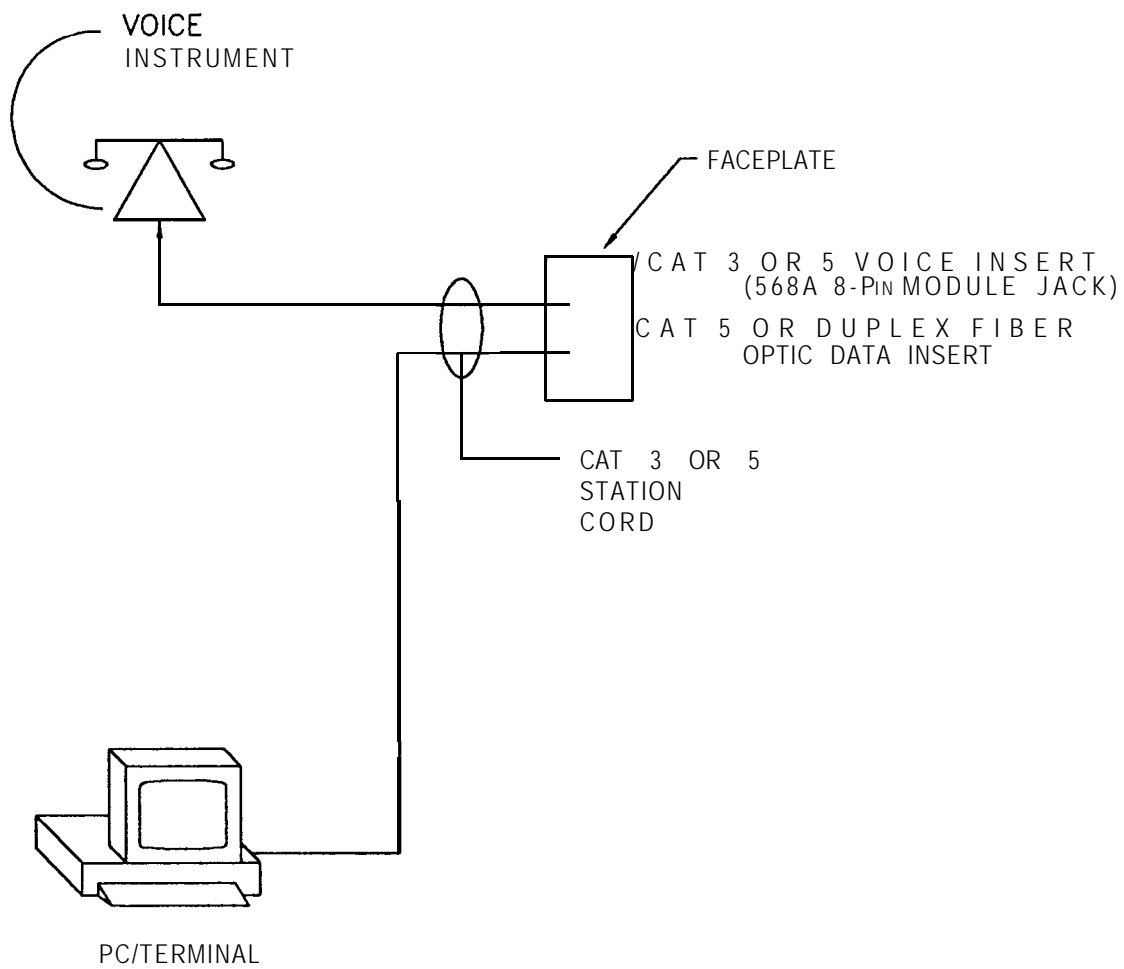


Figure 3
Standard Workstation

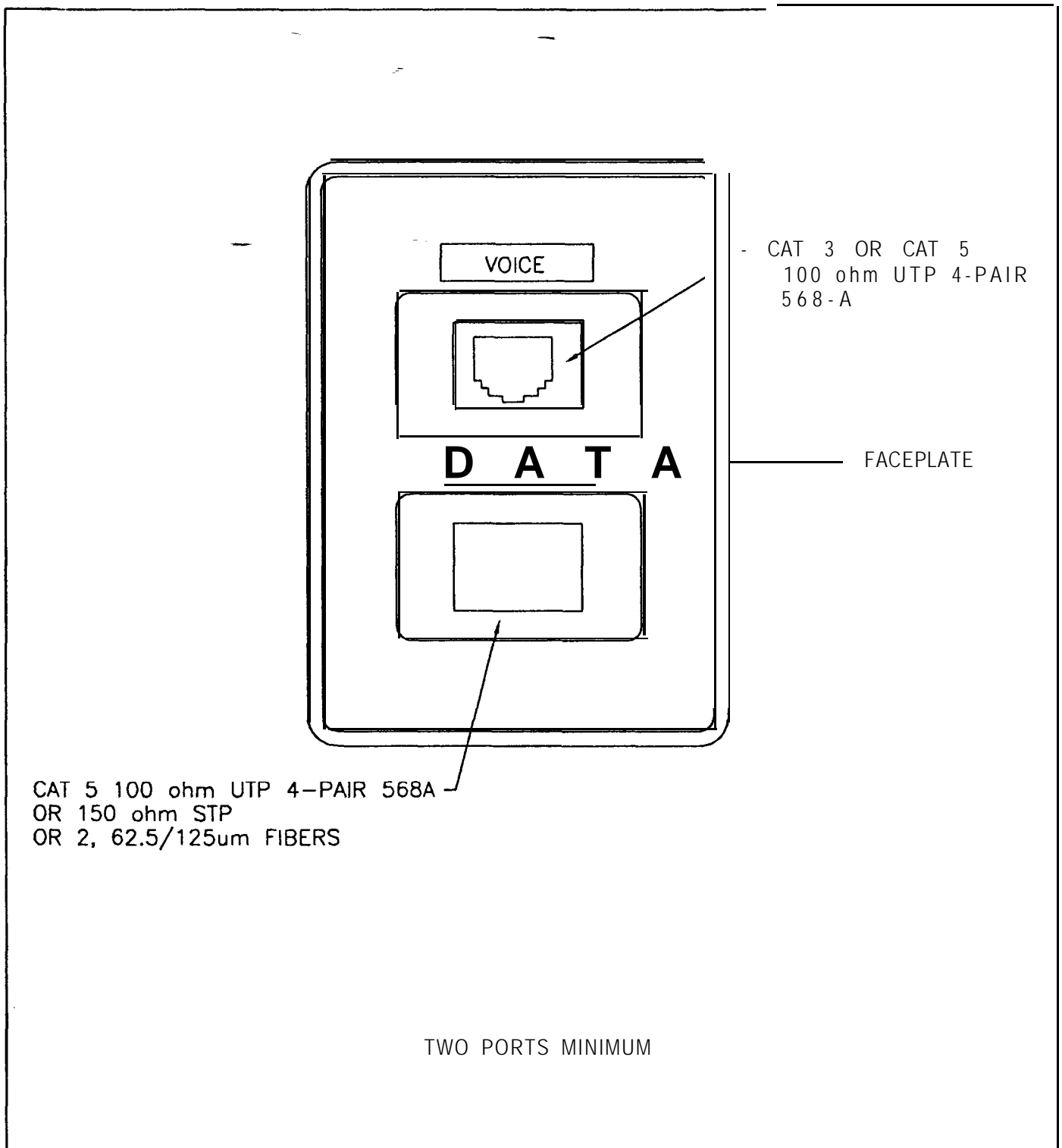


Figure 4
Telecommunications Outlet

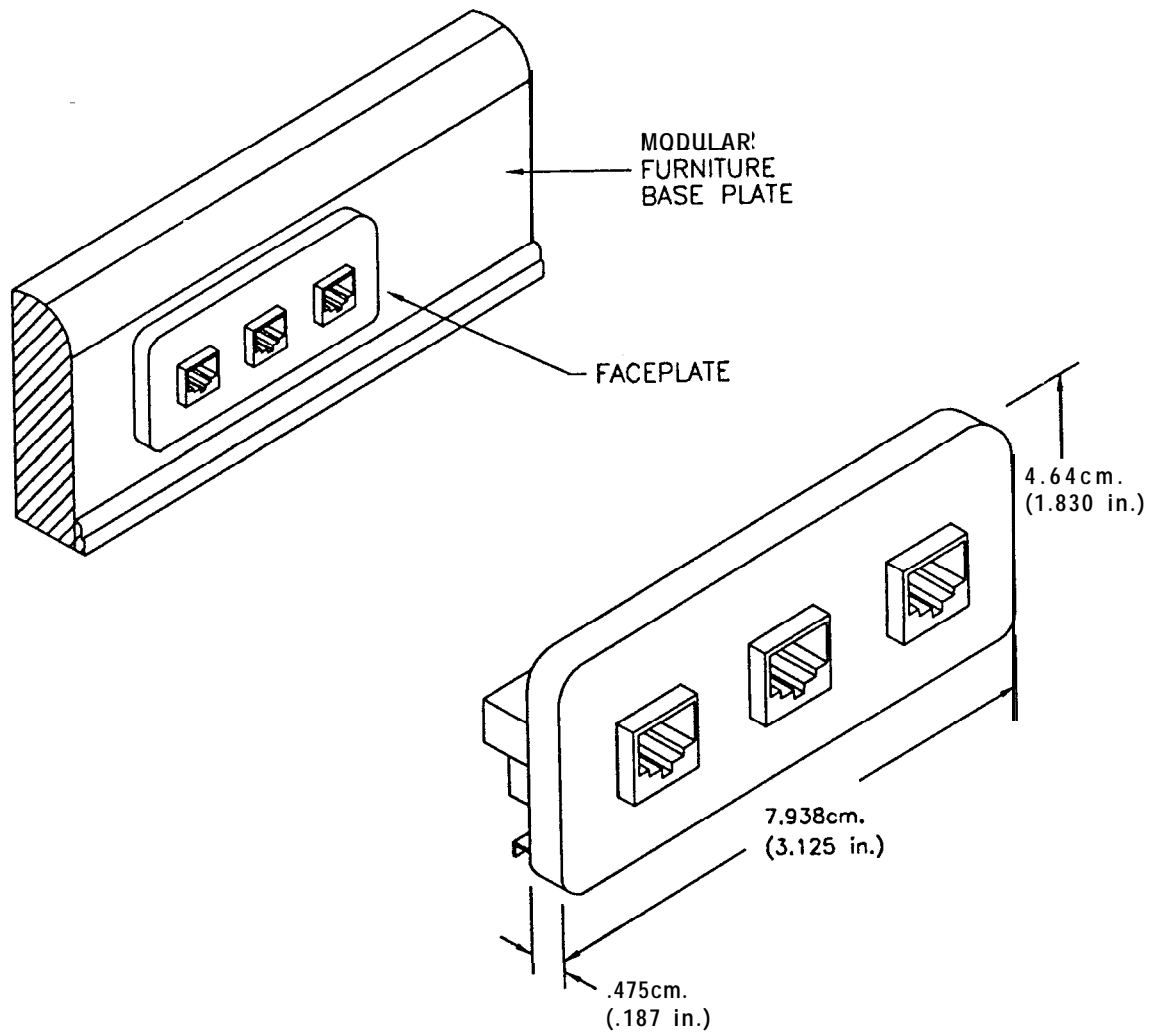


Figure 5
Modular Furniture Faceplate

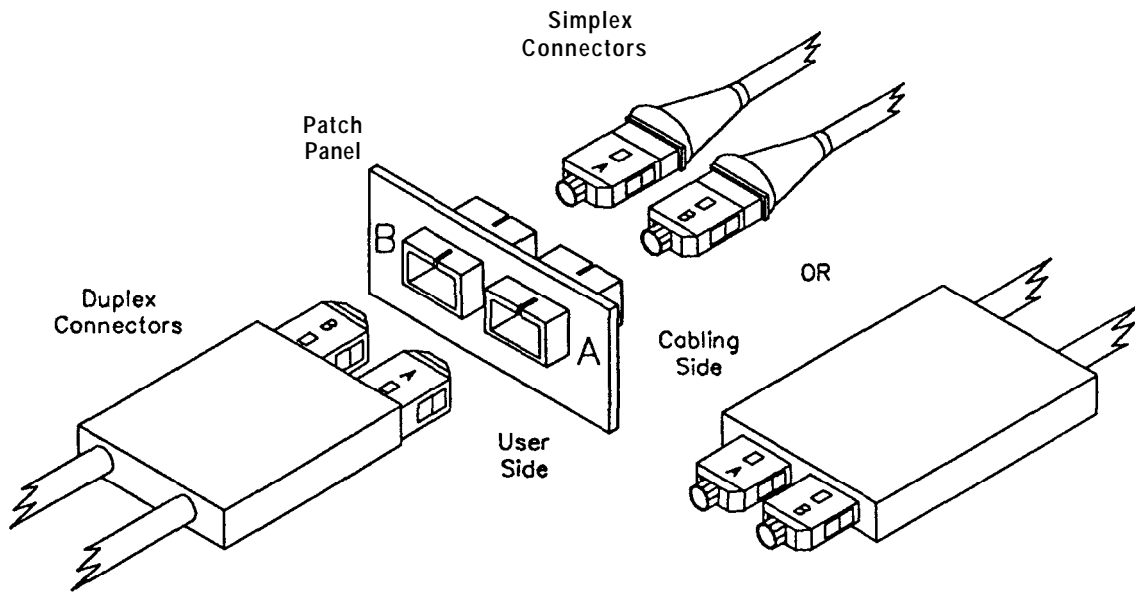
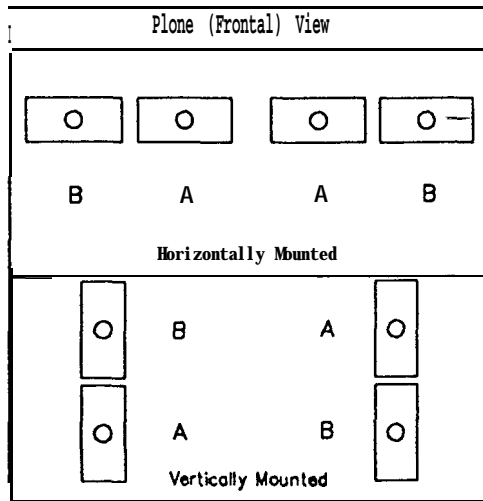


Figure 6
Duplex Fiber Optic 568SC Connector

1.3.2.5 Shielded 150 Ohm Cable. Two pair 150 ohm shielded cable is not recommended for new construction but may be encountered in the refurbishing of older buildings. Its presence may indicate an area of increased EMI and should be approached accordingly. Shielded cable is prevalent in Europe where electronic emission standards are more stringent.

1.3.3 Wall-Mounted Outlets and Conduit. Provide flush-mounted faceplate attached to a 103 cm (4 in.) square by 56 mm (2-1/8 in.) deep wall box in accordance with EIA/TIA 569. This requirement is designed to provide sufficient space to allow coiling of the cables within the box without exceeding the minimum bend radii. A reducer may be added to allow the attachment of a single-gang faceplate. The box should be connected to appropriately sized conduit which is stubbed up into an accessible ceiling, homerun to the serving telecommunications closet, or connected to an in-floor distribution system. Conduit sizes to support wall box configurations are dependent upon the number and diameter of the distribution cables being run. Conduit should be sized to accommodate the future installation of fiber to the desktop. Refer to par. 1.5.1.3.c) of this manual or EIA/TIA 569, Table 4.4-1, for assistance in sizing conduit. Wall boxes should be installed at the same height as the electrical outlets which is normally 42.5 cm (17 in.) above the finished floor (AFF) measured from the center of the box. Provide wall mounted outlet in kitchen area within housing units. Outlet shall be installed 120 cm (48 in.) AFF. Pay telephones are to be installed 100 to 105 cm (40 to 42 in.) AFF. The Americans With Disabilities Act requires that the highest operable mechanism on a pay telephone be within 135 cm (54 in.) side reach and 120 cm (48 in.) forward reach.

1.4 Horizontal Cable Requirements

1.4.1 Building Usage. The first step in quantifying building telecommunication cable requirements is the categorizing of the building by its type of telecommunications usage. Major usage types, as described below, each have both general and unique cabling requirements. When uncommon building types are encountered, the RCDD should consult the major claimant for specific distribution requirements. Cable distribution density within a building is dependent upon the buildings projected functions over a 10-year period. Pathways should be designed for the life of the building. Premature recabling is time consuming, expensive, and disruptive to both users and system operations. To correctly size the cabling infrastructure, the RCDD is encouraged to select one of the various building usage types listed below prior to computing the quantity and types of cables required to support each workstation and the type and size of the

period. Pathways should be designed for the life of the building. Premature recabling is time consuming, expensive, and disruptive to both users and system operations. To correctly size the cabling infrastructure, the RCDD is encouraged to select one of the various building usage types listed below prior to computing the quantity and types of cables required to support each workstation and the type and size of the horizontal pathway required to run the cables from the workstation to the telecommunications closets. This information will also be used in later subsections to size the telecommunications closets, backbone cables, pathways, and entrance facilities.

1.4.1.1 Administrative. Buildings being constructed or refurbished to house administrative personnel will most likely contain a combination of walled offices, usually adjacent to the windows, for supervisory personnel, conference facilities, and open bay areas toward the center of the floor plan. These open bays are commonly configured with modular furniture. Occupants of these buildings require general telecommunications support to each workstation for voice and LAN connectivity and specific telecommunications support to designated areas, as required to support the major claimant terminal equipment. Additional jacks not associated with a particular workstation will be required in common areas for the termination of facsimile machines, printers, and various terminal equipment. Activities which employ optical scanning and storage methods for large data files may require fiber optic cable to the workstations in designated areas for high-speed file retrieval. At a minimum, each walled office should contain a two-port faceplate, configured in accordance with EIA/TIA-568, for each occupant. At a minimum, it should contain an eight-pin modular voice jack, which is either CAT 3 or CAT 5 and either an eight-pin CAT 5 modular data jack or a duplex fiber optic data jack. The major claimant may specify a second or third data jack dependent upon anticipated LAN configurations. Installation of both CAT 5 UTP and fiber optic data cable to the workstation is allowed when required for compatibility with customer terminal equipment. When the major claimants' inputs are either not available or insufficient for detailed engineering, open bay areas should be engineered to provide for one workstation for every 10 sq. m (100 sq. ft.) of usable floor space. Each modular workstation should be equipped with one faceplate which is to be configured in accordance with the EIA/TIA 568.

MIL-HDBK-1012/3
Change 1, 30 November 1996

Furniture arrangements in open bay areas and the construction or demolition of walled offices will vary over the life of the building but the maximum number of occupants requiring telecommunications services within the building will remain at approximately one for every 10 sq. m. (100 sq. ft.) of usable work space. Example One serves to illustrate this estimation process.

EXAMPLE ONE

ESTIMATING THE NUMBER OF WORKSTATIONS

A. Number of Workstations Per Floor

1. The RCDD should consult with the major claimant to determine the projected occupancy.

Projected Occupancy _____.

2. Determine the number of potential occupants over the life of the building by dividing the usable square footage by 10 sq. m (100 sq. ft.).

Usable sq. m (sq. ft.)

Maximum number of occupants = $\frac{\text{Usable sq. m (sq. ft.)}}{10 \text{ sq. m (100 sq. ft.)}}$

3. Use the greater of 1. or 2. above as the number of potential workstations to be served. Even if horizontal cables are not initially run in this quantity, the pathways, backbone cables, telecommunications closets, and entrance facility must be constructed to eventually support workstations.

1.4.1.2 Headquarters. Telecommunications cables and pathways serving headquarters facilities, especially those housing flag and general officers, will require sufficient capacity to support unique point-to-point circuits in addition to the requirements outlined above for general administrative buildings. The designer should investigate the requirements for the following:

a) Additional entrance facilities to support above standard numbers of telephone and LAN cabling;

b) Antenna entrance facilities;

c) Additional fiber optic strands in the backbone for non-multiplexed circuits;

d) Expanded equipment room requirements to house voice switching equipment, above average amounts of electro/optical fiber optic convertors, multiplexers, transceivers, and communications and digital service units (CSUs/DSUs) for T-1 circuit terminations and bandwidth on demand multiplexers and coder/decoder (CODEC) for video teleconferencing;

e) Horizontal fiber optic distribution cables for video distribution and/or fiber to the desktop;

f) Video teleconferencing and video display connectivity to support conference facilities; and

g) Generators and other backup power devices.

1.4.1.3 Command and Control Center. In addition to those considerations listed above for headquarters facilities, cable and antenna service entrances, pathways, backbone systems, signal security, heating, ventilating, and air conditioning (HVAC), power tolerances, and floor loading must be given special attention when designing the telecommunications support for command and control facilities. Telecommunications equipment outlets should be served from the backup power distribution board. Raised floors are prevalent in the design of command and control facilities because of the increased number of interconnected consoles and multimedia workstation and display systems. Trunked mobile radio equipment, coaxial RF cabling, and an antenna mast or tower should be anticipated. MIL-HDBK-420, Site Survey Handbook for Telecommunications Facilities addresses the site survey procedures to be conducted prior to designing communications facilities and NAVELEX 0101/0102, Naval Shore Electronics Criteria addresses communications station design. For signal security considerations, primarily cryptologic equipment applications, MIL-HDBK-232, RED/BLACK Engineering-Installation Guidelines provides RED/BLACK signal distribution design guidance. Facilities which require sensitive compartmented information storage must comply with the Director of Central Intelligence (DCI) directive 1/21, Physical Security Standards for Sensitive Compartmented Information Facilities and NACSIM 5203, Guidelines for Facility Design and RED/BLACK Installation.

1.4.1.4 Training. Training facilities are both users and generators of high data rate circuits and employ both fiber optics and satellite radio transmission paths in association with distance learning. Provide a structured premises wiring system compatible with the customer's terminal equipment to include CAT 5 and fiber optic media.

Administrative areas, classrooms, and auditoriums may require both LAN and broadband video distribution jacks. Video cables will terminate in the video control room. Video distribution cables may be coaxial, fiber optic, or UTP.

1.4.1.5 Technical or Laboratory. The RCDD must consult with the major claimant regarding the short- and long-term usage planned for the facility. It may be anticipated that additional fiber optic media will be required to carry high-speed data directly across the campus to avoid delays inherent in multiplexed systems. This is prevalent where simultaneous related operational activities are being conducted or simulated in several campus locations and require real-time connectivity.

1.4.1.6 Hospital. Hospital facilities shall be designed in accordance with MIL-HDBK-1191, Medical and Dental Treatment Facilities Design and Construction Criteria, Department of Defense. The design of a telecommunications distribution system to serve a hospital requires that the RCDD become cognizant of the functionality of each area or room within the facility. Hospital telecommunication support requirements encompass extensive additional connectivity and unique installation criteria to accommodate nurse call, intercom, public announcing, master TV antenna, and other miscellaneous systems. The nurse call system provides the baseline communications between nurse stations, patient rooms, lab facilities, operating/treatment rooms, and doctors. It provides for emergency calls, routine patient requests, paging, and is used as a personnel locator.

The RCDD must ensure that the requirements for telecommunications cabling have been included with the other pathway requirements for security, electrical, alarms, and announcing systems. To adequately address the intra-building pathways and telecommunications cabling, the RCDD must at a minimum become familiar with Naval Facilities Guide Specifications (NFGS's). These guide specifications, along with the commercial standards, detail the cable configurations associated with the hospital telecommunications infrastructure. Selection of cable types is dependent on the interface requirements of the equipment supported by the cabling system. It is, therefore, imperative that the RCDD obtain space connectivity requirements and equipment interface data from the claimant organization and OEM. If claimant cannot provide accurate interconnection data, the designer should provide one fiber optic, two Category 3 UTP, and one Category 5 cable per bed or treatment area. This will accommodate the nurse call, telephone, and patient monitoring requirements. Each room should also be configured with either a coaxial or fiber optic cable for cable television (CATV) service. In addition to the nurse call system it is incumbent upon the RCDD to address the cabling support requirements for telephone and the transfer of information from medical monitoring equipment and data terminals.

Most hospitals today are training and research facilities with video monitoring and teleconferencing connectivity requirements. Additional connectivity to support access to mobile radio, including telemetry; paging; and satellite communications are standard requirements in most hospitals. The RCDD must ensure horizontal and backbone pathways fully meet the connectivity requirements of the hospital's communications assets. The distribution of extensive electrical, fire, alarm, security, video, and information transfer within the limited confines of a hospital building requires extensive coordination with the electrical and alarm design agents to ensure installation of adequate support structures for cable placement. Some hospitals are constructed with interstitial areas between floors through which utility pipes, ducts, and cables are run. Where this is not the case, cable routing should be provided via cable tray or wireway as defined by EIA/TIA 569. When possible separate or segregated distribution trays or ducts should be used for each application (fire, data, telephone, security, etc.). Routing of individual signal cables from the tray or wireway to the station box should be accomplished with electrical metallic tubing (EMT) conduit with compression fittings.

1.4.1.7 Bachelor Quarters. Bachelor quarters (BQs) are to be designed in accordance with MIL-HDBK-1036, Bachelor Quarters. BQs are to be configured with a minimum of a single faceplate per room. For dual occupancy bedrooms provide two single faceplates as shown in Figure 7. Additional LAN cabling may be considered.

The preferred distribution support structure for the UTP cable shall be via cable tray or wireway in the hallway ceiling. EMT conduit should be routed from the cable tray/wireway directly to the station boxes. Conduit and tray fill shall be in accordance with NFPA 70. Cable distribution services in multilevel BQs should be installed in accordance with the provisions of EIA/TIA 570, Residential and Light Commercial Telecommunications Wiring Standard. Horizontal telecommunication distribution closets should be located on each floor of the BQ. The horizontal distribution cables, four pair 24 AWG solid conductor wire, should be interconnected to the building entrance cable in these closets via multipair vertical backbone cables. As an alternative, access to CATV, telephone, and E-mail may be jointly routed to the rooms via a 75 ohm broadband coaxial cable.

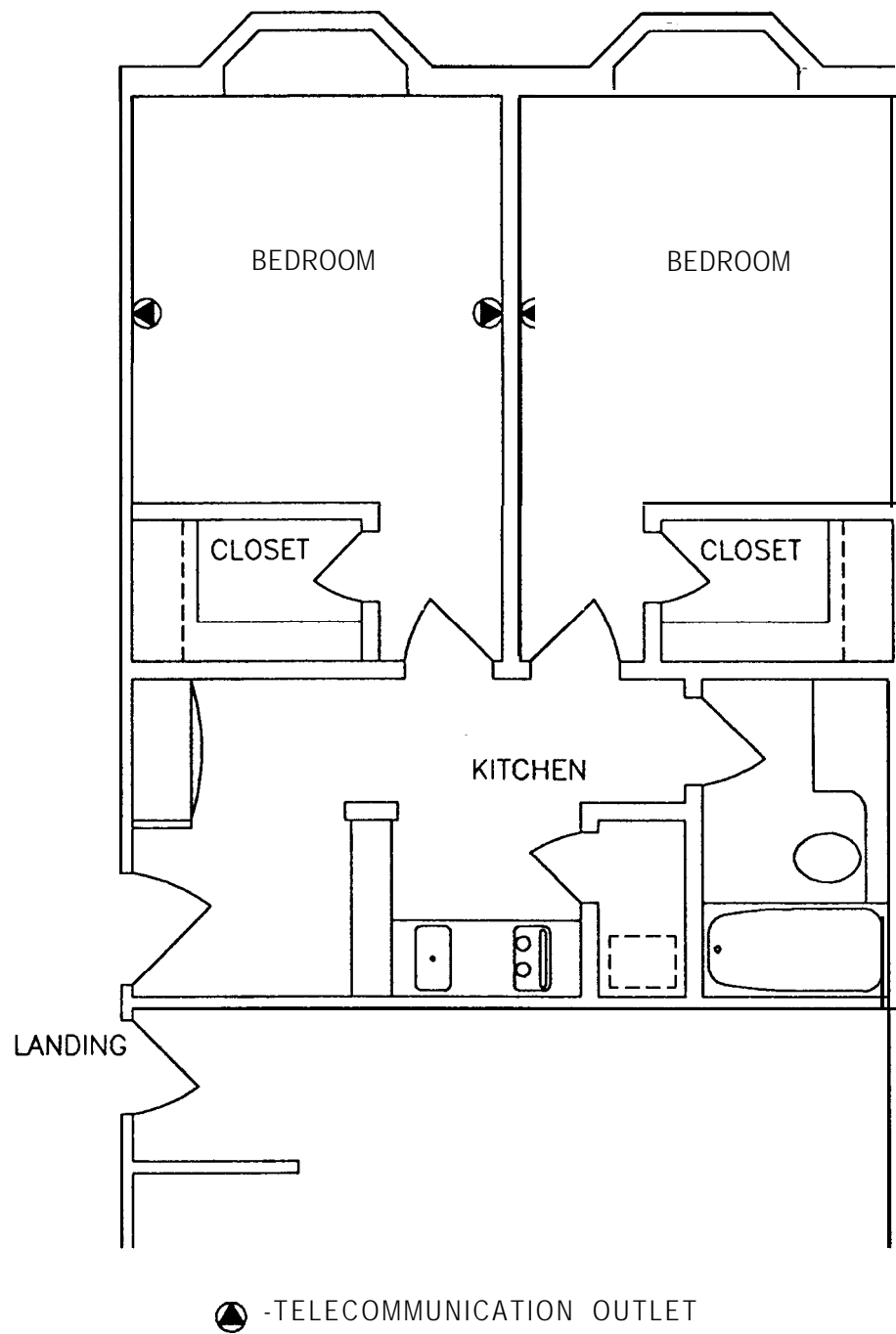


Figure 7
BQ Floor Plan

1.4.1.8 Single Family Housing. As described in MIL-HDBK-1035, Family Housing, single family housing is usually provided with telephone service by the local exchange carrier (LEC). During the construction phase, the Contractor shall be instructed to provide a direct burial six pair, 24 AWG cable from the property line, to the demarcation point in the building. In cases where the housing units are located within the confines of the Government facility and the outside plant is Government-owned, the distribution cables from several housing units should be run to a consolidation point, e.g., a pedestal or manhole, adjacent to the main telephone feeder cable run, since there is no property line associated with each unit. The six pair cable to the building is termed the "distribution cable." When attached to the demarcation point, it shall be properly grounded and terminated on lightning protectors. The demarcation point will serve to separate the LECs facilities and the premises wiring. A cable distribution device, capable of terminating eight LEC distribution pairs shall be mounted within 30 cm (12 in.) from the demarcation point. This distribution device will serve as an administration point and the origin of the star configured station drops to the various rooms. Cable distribution within single family housing units shall be installed in accordance with EIA/TIA 570. At a minimum, one CAT 3 UTP four pair cable shall be dedicated to each of the following rooms: kitchen/dining area, master bedroom, and the family/great room. These rooms will be configured with at least three jacks. Provide a dedicating second line to the family room and consider an additional line to other bedrooms and the study or den where feasible. Figure 8 depicts a typical two-story unit. The actual locations of jacks is dependent upon the floor plan of the unit. Each wall with an unbroken length of 4 m (12 ft.) or greater shall be configured with a telephone jack. The total configuration should ensure that no horizontal baseboard run can be made in excess of 8.3 m (25 ft.) before encountering a telephone jack. Jacks shall be a single or dual port flush-mounted wall plate configured with an eight-pin modular jack, wired in accordance with EIA/TIA 568. EIA/TIA 568 wiring may be substituted where specifically required by associated equipment. Up to three jacks within the same room, served by the same primary line, may be ganged together in series. Double gang, 103 cm (4 in.) square boxes shall be installed in the wall to accommodate the termination of the cables. Pathways equipped with pull string shall be provided back to the distribution device; 21 mm (3/4 in.) EMT is recommended. Each station cable shall be run from the distribution device in a star configuration. In the case of U.S. Army construction, family housing shall be wired in accordance with architectural engineering instructions (AEI) for family housing.

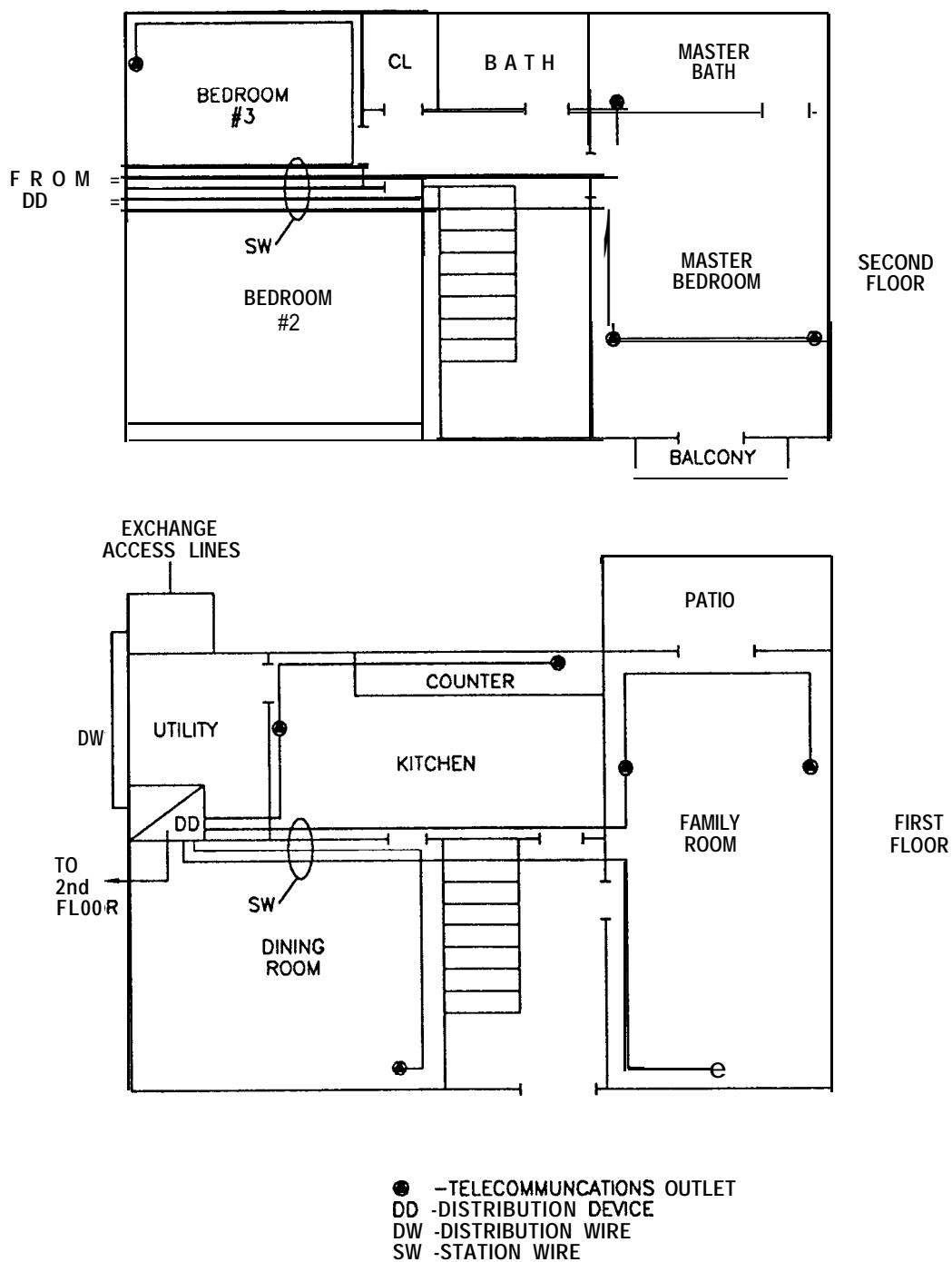


Figure 8
Single Family Housing Floor Plan

1.4.1.9 Guard Shack. Guard shacks are inherently difficult to upgrade because of remote physical locations (usually in the middle of traffic lanes) and their limited physical size. To ensure adequate connectivity for current and future requirements, a 12 pair cable and a 6 strand fiber optic multimode cable should be installed during construction. The 12 pair copper cable can provide ringdown service to each of the various emergency services usually available on a base (hospital, fire, security), as well as an on-base dial-up capability. The fiber optic strands will accommodate control and video signals from the video camera and provide access to security information databases after normal working hours. The copper cable should meet Rural Electrification Administration (REA) standards for the type of installation planned; PE-89, Filled Telephone Cables With Expanded Insulation for underground or buried and PE-22, Aerial and Underground Cable for aerial. The fiber optic cable should be tight buffered, loose-tube construction. Service to the guard shack should be provisioned through an underground 4-inch rigid conduit routed from the nearest campus distribution system access point (manhole, pole, or building).

1.4.1.10 Warehouse. The availability of supply/inventory data networks have enhanced the efficiency of warehouse operations to the point where warehouses are now a minicomputer center. Since the distances from the remote terminals usually exceed the recommended 90 m (295 ft.), these networks are serviced in various ways, including dial-up modem access, coaxial, and fiber optic connectivity. Most warehouse facilities are high-ceiling structures with areas sectioned off to provide for environmentally conditioned office and equipment spaces. When provisioning telecommunication services to a warehouse, the RCDD must account for the high volume, high-speed telecommunication requirements of the modern warehouse facility. Connectivity and distribution requirements in the environmentally conditioned office area should be configured the same as delineated for an administrative building. The horizontal distribution to entry terminal locations outside the office area should be in metal conduit (usually EMT) and routed along walls or ceiling beams to prevent inadvertent damage from the heavy equipment or vehicles which are common to the warehouse environment. When planning conduit routing for telecommunication cabling, the RCDD should avoid significant obstructions encountered in the space, sources of EMI, and areas where excessive heat conditions might exist. In the warehouse area, the RCDD should provide a wall phone jack approximately every 33 m (100 ft.). Paging systems are usually accessed through the telephone switch by dialing a specific code for the desired zone from a properly class marked instrument. In those instances where separate paging microphones are required, microphones should be collocated with the wall phone. Speakers

and external ringers should be located to provide overlapping coverage. Since most warehouse facilities exceed 90 m (295 ft.) in length, fiber optic connectivity to remote terminals located in the warehouse is recommended. Small numbers of data subscribers may be inexpensively extended beyond the 90 m (295 ft.) restriction by applying individual UTP/fiber optic transceivers to these drops.

1.4.1.11 Miscellaneous. Buildings not specifically covered herein may be comprised of a combination of several building types or they may be unique. When they are unique, the major claimant shall be approached for distribution requirements.

1.5 Horizontal Pathways. Horizontal pathways are structures used to protect, support, and conceal the horizontal distribution cables which run from the workstations to the serving telecommunications closets. The number of cables to be run, their sizes, bend radii, cost, and construction design of the building are all considerations in determining the pathway type. More than one type may be used within a building. The RCDD may or may not be afforded an input into the architectural decision whether to run the horizontal pathways within the floor or the ceiling structure but should review their number and size. The design of the pathway must be documented in the construction drawings to eliminate conflict with HVAC and electrical systems also being installed in the same areas. It is imperative that the RCDD properly size the horizontal pathway to support the estimated building life and ensure that they are installed properly to avoid EMI or congestion. Generally data cables from the workstation jack are to be home run to the serving telecommunications closet to comply with the EIA/TIA 568 restriction to two cross connect points. However, there may be instances where the user population is so fluid as to require frequent relocation and rewiring of workstations. This is common in large areas populated with modular furniture. The cost of rerunning these cables all the way back to the closet for each relocation may be reduced by using a zone distribution to the center of the area and coiling extra cable, not to exceed a total length of 90 m (295 ft.) in the ceiling. Another option, while not normally recommended, is to disregard the EIA/TIA 568 standard that allows only two cross connect points and install a zone distribution cross connect point within the work area. The zone distribution box would be permanently cabled from the serving telecommunications closet and then extended by an additional distribution cable to the workstation. Relocation of the workstations or addition of a workstation would require that a cable be pulled from the zone distribution box to the workstation faceplate rather than from the closet to the workstation.

1.5.1 Types of Horizontal Pathways. The following paragraphs list the various types of horizontal pathways, their advantages and disadvantages, design criteria and installation parameters as specified in EIA/TIA 569 and NFPA 70.

1.5.1.1 Underfloor Duct. Underfloor duct systems are comprised of a number of horizontal perpendicular raceways embedded in the concrete floor of a building. While they may be used to support both power and telecommunications, the two should not be mixed within one duct without approved separators and must comply with local and national electrical codes. Refer to NFGS-16130, Underfloor Raceway System for additional information. These duct systems may be single, double, or triple level depending on the requirement and the thickness of the floor as shown in Figures 9, 10, and 11. Underfloor duct systems may be comprised of enclosed rectangular ducts or raceways, open trenches with screw-on covers, or a combination of these. For the purpose of this description cellular floors are also included as underfloor ducts. Underfloor duct systems use an access hole through the floor and/or carpet at the junction point to gain access to the duct for pulling cables. Access holes are also required for the placement of inserts at cable service points.

Installed underfloor ducts are categorized as either feeder ducts or distribution ducts. Feeder ducts run from the telecommunications closet to a junction point. Distribution ducts join the feeder ducts at right angles and run from the junction point to the outlet jacks. There are no inserts in feeder ducts.

a) Advantages of underfloor ducts and cellular systems include:

- (1) Physical protection of distribution cables;
- (2) Out-of-sight cable runs;
- (3) Reduced EMI due to metal shielding (requires proper grounding and bonding);

(4) Frequent access at predetermined intervals;
and

- (5) No requirement for plenum cable.

b) The disadvantages of underfloor ducts and cellular systems include:

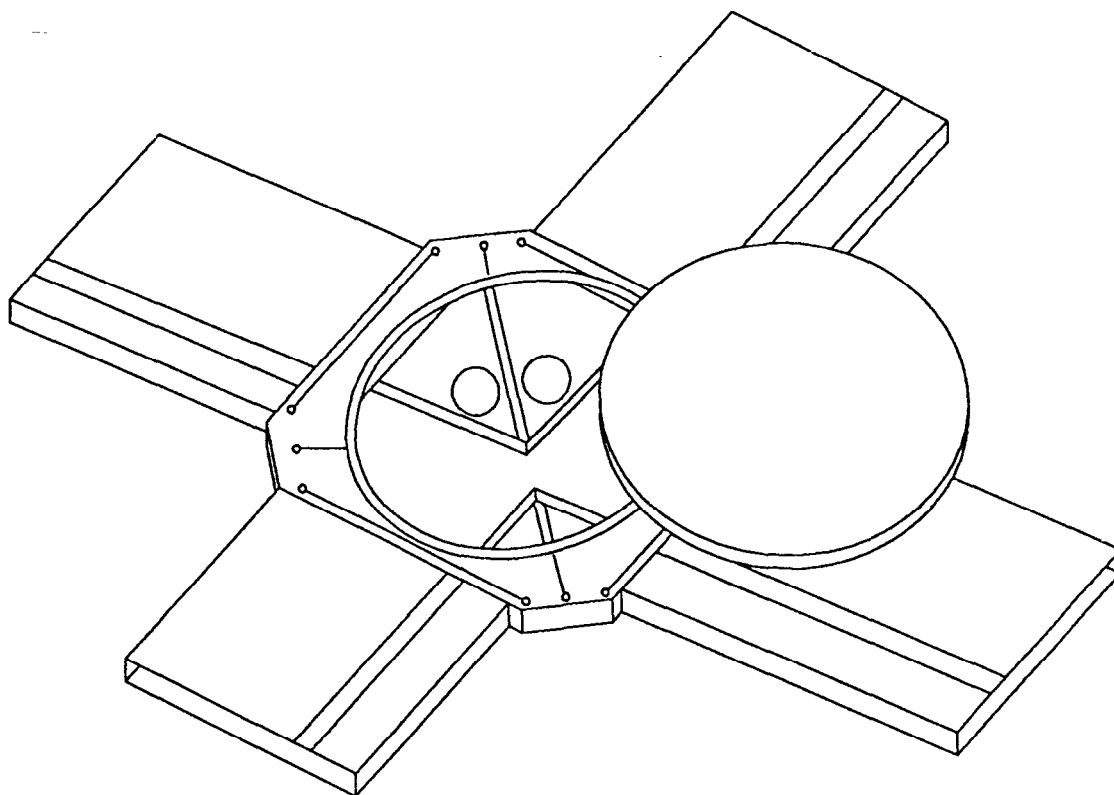


Figure 9
Single-Level Underfloor Duct

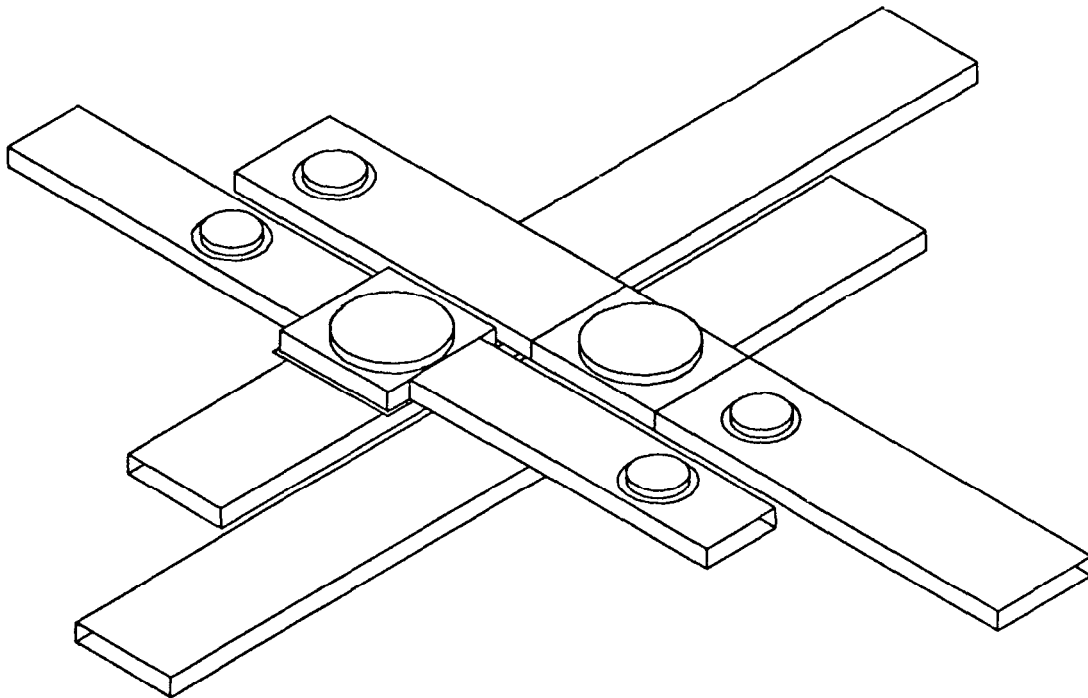


Figure 10
Two-Level Underfloor Duct

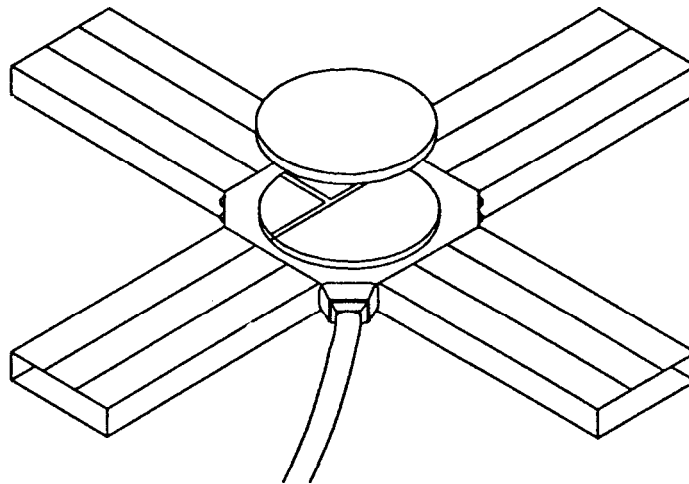


Figure 11
Flush Duct Underfloor System

(1) Even though the in-floor ducts or cellular system components reduce the amount of construction material required for the floor and in the case of cellular strengthens the floor, their cost is high;

(2) Junction boxes are required at each 90-degree turn and may become saturated over time;

(3) Access hole may not be easily accessible once furniture has been placed;

(4) New access holes require a core bore through the floor and into the duct which could damage existing cables; and

(5) These systems do not lend themselves to frequent system reconfiguration.

c) In-floor pathways shall conform to the design criteria of EIA/TIA 569, par. 4.2 which delineates the fill capacity and concrete cover depth requirements for each type. The practice of allocating two cables and 10 sq. m (100 sq. ft.) of workspace to each workstation results in an industry practice of designing 6.25 sq. cm (1 sq. in.) of cross sectional duct for each workstation. This applies to both feeder and distribution ducts (EIA/TIA 568, par. 4.2.1.4.1). Refer to Example Two for assistance in estimating quantities of in-floor ducts. The horizontal distance restrictions of EIA/TIA 568 (295 ft.) apply. BICSI recommends that the distribution duct nearest the wall parallel to the run be located 18 in. to 24 in. from the wall, to allow room for furniture along an office wall, and the remaining ducts spaced at convenient intervals between the building supports. Preset inserts for access to the cables shall be located at regular intervals depending on the furniture design but at least every 17 m (50 ft.). Ducts shall enter the telecommunications closet either via a floor trench located along the closet wall or through elbows that terminate beneath the plywood backboard of the closet. Elbows shall terminate 5 cm (2 in.) AFF.

EXAMPLE TWO

ESTIMATING IN-FLOOR DUCT

A. Distribution Duct. In-floor distribution duct requirements may be estimated by applying a guideline of 6.5 sq. cm (1 sq. in.) of duct cross-sectional area for each 10 sq. m (100 sq. ft.) of usable floor space served. Assuming that no more than three cables will be pulled to each workstation and each workstation occupies 10 sq. m (100 sq. ft.), the total length of in-floor distribution duct may be estimated as follows:

1. Calculate:

Length of distribution ducts = length of the area served by the telecommunications closet (l) multiplied by the width of the same area (w) divided by the duct separation 1.7 m (5 ft.), plus the length of the area (l).

Note: An additional length of the service area is added in this calculation to account for the cost of a duct being installed within 24 in. of both outside edges of the service area.

$$\begin{aligned}\text{Length of distribution ducts} &= (L \times W / 5) + L = \\ &= \frac{(l \times w)}{5} + l\end{aligned}$$

2. Example: If the distribution zone is 100 ft. long and 100 ft. wide:

$$\begin{aligned}\text{Length of distribution ducts} &= \frac{(100 \times 100)}{5} + 100 \\ &= (10,000/5) + 100 \\ &= 2000 + 100 \\ &= 2100 \text{ ft.}\end{aligned}$$

	Range of Cross-Sectional Area
Duct Size	
Standard	21 to 25 sq. cm (3.3 to 3.9 sq. in.)
Large	49 to 57 sq. cm (7.6 to 8.9 sq. in.)

EXAMPLE TWO (Continued)

B. Feeder Ducts. For estimating purposes a standard feeder duct of 50 sq. cm (8 sq. in.) may be allotted for each 80 sq. m (800 sq. ft.) of usable floor space (typical area feeder duct will service).

1. Calculate:

(a) Number of feeder ducts = usable floor space divided by 800 sq. ft.

Number of feeder ducts = usable floor space = _____
800 sq. ft.

Example: If the usable floor space is 10,000 sq. ft. then:

Quantity of feeder ducts = $\frac{10,000 \text{ sq. ft.}}{800 \text{ sq. ft.}}$
= 12.5
round up to = 13

(b) Total length of feeder ducts = number of feeder ducts times their average length (distribution area width/4 or 2).

(1) For a centrally located telecommunications closet, divide the width of the distribution zone by 4 and multiply by the number of feeder ducts required:

Total length of feeder duct = $\frac{(\text{width})}{4} \times \text{no. of ducts}$ ____ = ____

EXAMPLE TWO (Continued)

Example: If the width of the distribution zone is 100 ft. and the quantity of feeder ducts required is 13 then:

$$\begin{aligned}\text{Length of feeder duct} &= \frac{(100 \text{ ft.})}{4} \times 13 \\ &= 25 \text{ ft.} \times 13 \\ &= 325 \text{ ft.}\end{aligned}$$

(2) For a telecommunications closet located toward either edge of the distribution zone, divide the width of the distribution zone by 2 and multiply by the number of feeder ducts required:

$$\text{Total length of feeder duct} = \frac{(\text{width})}{2} \times \text{no. of ducts} \quad \underline{\hspace{1cm}} = \underline{\hspace{1cm}}$$

Example: If the width of the distribution zone is 100 ft. and the quantity of feeder ducts required is 13 then:

$$\begin{aligned}\text{Length of feeder duct} &= \frac{(100 \text{ ft.})}{2} \times 13 \\ &= 50 \text{ ft.} \times 13 \\ &= 650 \text{ ft.}\end{aligned}$$

d) In accordance with NFPA 70, Articles 300 and 354 and EIA/TIA 569, par. 4, in-floor duct systems shall be installed:

(1) Under 21 mm to 25 mm (3/4 in. to 1 in.) of concrete cover depending on the size of the raceway or flush with the floor and covered with floor covering;

(2) With trench cover, where applicable, flush with the floor;

(3) Maintaining a maximum 40 percent fill ratio; BICSI also recommends an additional 15 percent reduction in fill for each 90-degree bend. Consequently, a 40 percent fill with two 90-degree bends would be reduced to a 28 percent fill.

(4) Laid in straight lines with feeder ducts or trenches perpendicular to the distribution ducts;

(5) With junction boxes and inserts level with the floor and sealed to prevent the entry of moisture; and to interface with wall outlets using a properly bonded and grounded metallic conduit.

e) Cellular floor systems, unlike duct or trench systems serve as a structural floor. The modules are composed of a rolled top and a flat bottom and may be obtained in either steel or concrete construction. Cellular floor planing must be coordinated with the structural engineer. Cellular floor modules are available in two-, three-, or four-cell configurations. Various widths and depths are available to provide the connectivity required. The RCDD must know the area to be served and the number and diameter of the distribution cables to determine the size and number of cells.

f) In accordance with NFPA 70, Articles 300, 356, and 358 and EIA/TIA 569 , par. 4, cellular floor systems shall be installed:

(1) On 1.2 m to 1.5 m (4 in. to 5 in.) centers with 50 percent of the modules allocated to cells and the remaining modules non-cell (cells are 5 cm (2 ft.) wide and non-cells are 5 cm to 7.5 cm (2 in. to 3 in.) wide);

(2) With preset inserts on 60 cm (24 in.) centers;

(3) So that distribution cells run the length of the building to reduce feeder duct length; and

(4) Maintaining a maximum 40 percent fill ratio; BICSI also recommends an additional 15 percent reduction in fill for each 90-degree bend. Consequently, a 40 percent fill with two 90-degree bends would be reduced to a 28 percent fill.

1.5.1.2 Ceiling Distribution System. Ceiling distribution systems are an inexpensive alternative in areas where non-locking suspended ceiling tiles are to be installed and where local codes allow loose cables to be run within ceilings. Within the ceiling the cables may be supported by trays, rings, or hooks suspended from the ceiling or wall structure. A zone distribution system may be desirable whereby cables are run from the closet in conduit or tray to the center of the area to be served and distributed from there to the workstations using a suspension arrangement as described above. Where possible wall jacks should be stubbed up into the false ceiling, using appropriately sized EMT, as close to the zone distribution point as practical. Par. 1.5.1.3.c) and EIA/TIA 569, Table 4.4-1 provide assistance in sizing conduit.

a) The following advantages may be attained through the use of ceiling distribution systems:

- (1) Low initial cost;
- (2) Installation is easy to perform and requires minimal time;
- (3) Installation can also be done after construction has been completed;
- (4) Low-cost moves, adds, and changes. Outlets can be relocated short distances using the same cable;
- (5) Flexible pathway; and
- (6) Pathway is dedicated to a specific floor area;

b) The following disadvantages are indigenous to ceiling distribution systems:

- (1) Can be installed only in false ceilings;
- (2) Require expensive plenum rated cable when run in an HVAC plenum ceiling;
- (3) Are susceptible to EMI if not installed properly; and
- (4) May require utility columns to reach the center of open areas.

c) If cable trays are not installed, then cable support devices such as rings or hooks must be suspended from the wall, ceiling, or ceiling support structure using 10 cm (3/8 in.) all-thread attached to the structure with anchors or beam clamps. These devices should be located on 1.3 m to 1.7 m (4 ft. to 5 ft.) centers. Ceiling support wires or rods will not be used to support cables. Cable runs should be designed using perpendicular paths with 90-degree turns comprised of two 45-degree turns. A zone distribution system may be used. If the ceiling air space is being used as the air return path for the HVAC system, plenum cable must be used. This will noticeably increase the cost of the installation. A cost/benefit analysis for comparison with other suitable distribution methods should be performed. Utility columns or building support columns may be used to access the workstations. Flush mount wall jacks will be stubbed up into the ceiling in accordance with NFPA 70. Where

solid cement or block walls exist, which is common in buildings being refurbished, a surface-mounted wireway must be attached to the wall.

d) Cable sag should be minimized to reduce the stress on the cables and to avoid interference with the removal of ceiling tiles. A separation of 152 mm to 305 mm (6 in. to 12 in.) must be retained between the sag and the ceiling support bar. Care must be taken to avoid sources of EMI, such as motors (common in HVAC), power distribution cables, copy machines, and fluorescent lighting. Telecommunications cables and pathways should cross fluorescent lights, conduits, and metallic cables at right angles. Distances to be maintained from sources of EMI as specified by EIA/TIA 569 are as follows:

- (1) 1.3 m (4 ft.) from large motors and transformers;
- (2) 27 cm (1 ft.) from cables and conduit used for electrical power distribution; and
- (3) 129 mm (5 in.) from fluorescent lighting.

1.5.1.3 Conduit Systems. With the exception of ceiling zone distribution systems, conduit pathways are dedicated home run paths from the station jack to the telecommunications closet. Up to three jacks may be ganged together. These dedicated runs result in reduced flexibility. Conduit may be constructed of EMT, rigid metal conduit, or rigid polyvinyl chloride (PVC).

a) Advantages of conduit distribution include:

- (1) Placing conduit in the floor during construction presents a low-cost unobtrusive path-to-wall outlet in low user density areas;
- (2) Conduit presents a clean solution to serving a few floor outlets in an area where a ceiling distribution system will be used to serve the majority of the users;
- (3) Eliminates the need for plenum cable; and
- (4) Can be used to protect cables from corrosive atmosphere or physical damage.

b) The following are the major disadvantages of conduit systems:

(1) Conduit must be placed in the floor during construction. This results in a loss of flexibility should pathway expansion be necessary;

(2) Use of conduit for telecommunications horizontal pathways is restricted by EIA/TIA 569, par. 4.4.1.2 to permanent locations in low device density areas.

c) In accordance with EIA/TIA 569, par. 4.4.2.1, conduit shall be installed so that no more than two successive 90-degree bends occur without placing a pull box. A pull box will also be installed every 31 m (100 ft.). Pull boxes shall be sized in accordance with EIA/TIA 569, par. 4.4.2.6.4. The bend radius of the conduit shall be six times the inside diameter for conduits 53 mm (2 in.) and smaller and 10 times the inside diameter for those larger than 53 mm (2 in.) and for conduits carrying fiber optic cable. Condulets (lb) are not considered pull boxes and are not recommended because of the inherent difficulty in maintaining minimum bend radii. Conduits are sized according to their allowable fill ratio. The fill ratio depends on the number and size of cables being run in the conduit. Example Three and EIA/TIA 569, Table 4.4-1, provide guidance for sizing conduit. Conduits may be run within cement floors and ceilings and may gang not more than three wall boxes together. Where ganging occurs conduit sizing shall increase incremental as cables are added.

d) Conduit runs shall be grounded and bonded in accordance with NFPA 70, Article 300.

EXAMPLE THREE

DETERMINING CONDUIT SIZE

A. The size of the conduit to be installed should be based on the size and quantity of the cables that are anticipated to be installed in it. Requirements for specific types of conduit, such as EMT, rigid metal, and rigid PVC can be found in NFPA 70.

B. Conduit fill should not exceed 53 percent when one cable is placed in the conduit, 31 percent when two cables are placed in the conduit, and 40 percent when three or more cables are placed in the conduit.

C. Conduit is to be sized in accordance with NFPA 70 and EIA/TIA 569.

EXAMPLE THREE (Continued)

D. To determine the conduit size:

1. Determine the outside diameter of the cables that will be installed in the conduit. For four-pair CAT 5 UTP assume 6.1 mm (.24 in.).

Diameter of Cables _____ in.

Number of Cables _____

2. Use the chart below from NFPA 70 to identify appropriate conduit size.

Conduit Trade Size		Number of Cables or Wires									
		Cable/Wire Outside Diameter, mm/in.									
		3.3 (.13)	4.6 (.18)	5.6 (.22)	6.1 (.24)	7.4 (.29)	7.9 (.31)	9.4 (.37)	13.5 (.53)	15.8 (.62)	17.8 (.70)
mm	in.										
16	(1/2)	1	1	0	0	0	0	0	0	0	0
21	(3/4)	6	5	4	3	2	2	1	0	0	0
27	(1)	8	8	7	6	3	3	2	1	0	0
35	(1 1/4)	16	14	12	10	6	4	3	1	1	1
41	(1 1/2)	20	18	16	15	7	6	4	2	1	1
53	(2)	30	26	22	20	14	12	7	4	3	2
63	(2 1/2)	45	40	36	30	17	14	12	6	3	3
78	(3)	70	60	50	40	20	20	17	7	6	6
91	(3 1/2)	-	-	-	-	-	-	22	12	7	6
103	(4)	-	-	-	-	-	-	30	14	12	7

Note: For 6.1 mm (.24 in.) diameter UTP cables nothing less than 3/4 in. should be used.

Example:

If no. of cables = 6 and all cable diameters = .24 in.

Conduit size = 1 in.

1.5.1.4 Access Floors. Access floors (raised or computer flooring) provide a convenient means of interconnecting telecommunications equipment. They are composed of antistatic modular floor panels supported by pedestals which may or may not be braced.

a) Access floors afford the designer the following advantages:

- (1) Handle high cable densities;
- (2) Pathway is easily accessible;
- (3) Offer least cost solution for making moves, adds/changes;
- (4) Aesthetically acceptable; and
- (5) Provide an enclosed plenum for HVAC feed or return.

b) Disadvantages of access floors include the following:

- (1) High initial cost;
- (2) Reverberate sound; and
- (3) If left removed or with unused holes, create a personnel hazard.

c) Access floors should be braced with stringers in areas where floor panels are frequently removed or the access floor is greater than 6 in. off the finished floor. Floor loading must be designed in accordance with EIA/TIA 569, Table A1-1. Access floors required ramps for equipment carts and handicapped access. These ramps require excessive space. In new construction the area to receive a raised floor shall be depressed to a depth equal to the height of the access floor. The height of the access floor in an office space should be a minimum of 155 mm (6 in.). In a computer or equipment room, or where the area beneath the floor is used as an HVAC plenum the minimum height of the access floor shall be 310 mm (12 in.) in accordance with EIA/TIA 569, par. 4.3.3.2.1.

d) Metal parts of access floors shall be UL listed and bonded to ground in accordance with EIA/TIA 569, par. 4.3.4.4.

1.5.1.5 Tray and Ladder Systems. Cable trays and ladders are rigid structures installed for orderly routing, support, and containment of telecommunications cables. Various types are available ranging from open ladders to closed or open top troughs. As with in-floor ducts, trays may be sized by allocating 6.25 sq. cm (1 sq. in.) of cross sectional area to every 10 sq. m (100 sq. ft.) of usable floor space being served. Tray and ladder systems may be run above or below the ceiling and under access floors. These wireways should be supported by brackets, rods or trapeze every 129 mm (5 ft.). A minimum of 310 mm (12 ft.) must be provided and maintained above the wireway. Coordination with the electrical and HVAC engineers is required to avoid conflicts in space allocation. Where solid or slotted ladder/tray bottoms are not mandated, care should be taken to avoid applying excessive cable weight over CAT 5 or fiber optic cables. Excessive weight may result in crimped CAT 5 or fractured fiber.

1.6 Telecommunications Closets. The telecommunications closet serves as the transition point between the horizontal and vertical distribution pathways. It is the cross connect point between the backbone and the horizontal distribution cables serving the workstations in the area. To function in this capacity the telecommunications closet must contain: cross connect fields, patch panels, fiber optic interfaces, and LAN hardware. Depending on the customer LAN requirements, it may also house electronic equipment for remote distribution of voice and video. Where central LAN and PBX switching equipment is collocated with horizontal distribution cross connects, the closet should be termed "equipment room" as described in par. 1.8.9. This handbook does not address electrical power distribution, environmental monitoring systems, various alarms, design of digital switch systems, LAN hardware, or the logical network configuration. The RCDD, however, will be responsible for ensuring that the telecommunications closets and the equipment room are sized and equipped to accommodate these systems. The telecommunications closet must be centrally located in the area being served so that horizontal cable runs are minimized and no horizontal cable run is greater than 90 m (295 ft.). If this is done, the average cable run should be approximately 30 m (100 ft.). There will be a minimum of one closet per floor. Additional closets will be required if the floor area exceeds 1000 sq. m (10,000 sq. ft.) or because of the shape of the area the horizontal distribution distance to the workstation exceeds 90 m (295 ft.). Multiple closets serving the same floor shall be linked together by a minimum of one 78 mm (3 in.) conduit. A 200 pair copper cable and 12 strands of

multimode fiber optic cable should be installed in the conduit for network connectivity and redundant routing. Figure 12 depicts a typical telecommunications closet.

1.6.1 Telecommunications Closet Requirements. The closet shall be sized in accordance with EIA/TIA 569, Table 7.2-1 which will result in a room ranging in size from 7 sq. m to 11 sq. m (70 sq. ft. to 110 sq. ft.). Refer to Example Four.

a) The ceiling should be a minimum of 2.6 m (8.5 ft.) high with no false ceiling.

b) Doors shall be a minimum of 1 m (3 ft.) wide and open outward.

c) A 1 m (3 ft.) clearance shall be maintained in front of cross connects and equipment racks.

d) A minimum of two dedicated 20 ampere 110 volt ac duplex receptacles shall be provided for equipment rack power, preferably served from the UPS power panel. Additionally, duplex convenience outlets shall be spaced at 2 m (6 ft.) intervals around the perimeter walls. Sleeves, slots, and wall penetrations shall penetrate the room 27 mm to 78 mm (1 to 3 in.) and shall be properly firestopped.

e) HVAC shall be provided on a 24-hour basis.

f) A 41 mm (1-1/2 in.) conduit shall be provided from the equipment room to the building grounding electrode. Closets shall be connected to a single point ground. In accordance with EIA/TIA 607, Commercial Building Grounding and Bonding Requirements for Telecommunications.

g) Lighting shall be a minimum of 540 lux (50 footcandles) at 1 m (3 ft.) AFF.

h) A minimum of two walls shall be covered with 21 mm (3/4 in.) fire rated, void free plywood. The plywood shall be painted with two coats of light colored fire retardant paint.

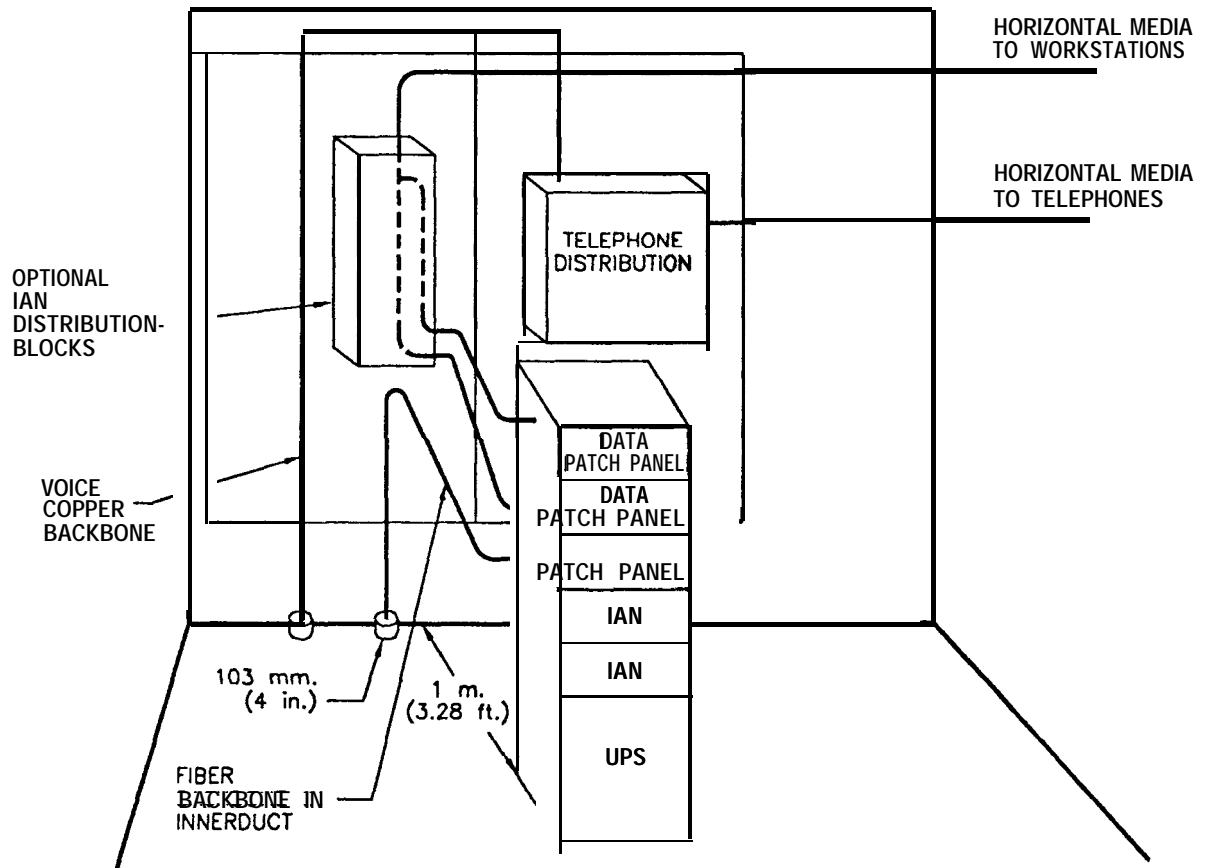


Figure 12
Telecommunications Closet

EXAMPLE FOUR

DETERMINING NUMBER AND SIZE OF TELECOMMUNICATIONS CLOSETS

A. Assuming a population density of one workstation every 10 sq. m (100 sq. ft.), a dedicated telecommunications closet for a building or floor which comprises less than 1,000 sq. m. (10,000 sq. ft.) should be sized as follows:

Service Area	Closet Size
Less than 500 sq. m (5000 sq. ft.)	-3.1 m x 2.2 m (10 ft. x 7 ft.)
500-800 sq. m (5000-8000 sq. ft.)	-3.1 m x 2.8 m (10 ft. x 9 ft.)
800-1000 sq.m (8000-10,000 sq. ft.)	-3.1m x 3.4m (10 ft. x 11 ft.)
Greater than 1000 sq.m (10,000 sq. ft.)	One closet per every 1000 sq.m(10,000 sq. ft.)

B. For buildings or floors with usable floor space in excess of 1000 sq. m (10,000 sq. ft.), the number of telecommunications closets may be estimated by dividing the total usable floor space by 1000 sq. m. (10,000 sq. ft.).

Number of closets = Total usable floor space = _____
1000 sq. m (10,000 sq. ft.)

1.7 Horizontal Cable Installation and Termination. Installation of fiber optic and copper distribution cables must be performed in accordance with the instruction provided in FIPS 174, Federal Building Telecommunications Wiring Standard as updated in EIA/TIA 568 and the recommendations of the manufacturer. CAT 5 cable is designed and manufactured to stringent standards of NEMA WC 63, Premise Telecommunications Cables (ICEA S-90-661) so that each pair will conform to the near end cross talk (NEXT) and attenuation parameters required to transmit 100 MHZ over a distance of 100 m (328 ft.). The manufacturing process is monitored and certified by independent third party certification entities such as Underwriters' Laboratory (UL). Installation of fiber optic and CAT 5 cables requires special handling during the installation and termination phases to prevent physical damage or alteration to the cable. In the case of CAT 5 cable the rate of twist and physical relationship of the pair within the cable jacket directly affects the electrical performance of the cable. The negative effects realized through alteration of the cable by twisting, kinking, overcinching of cable ties, or sharply bending it are directly proportional to the frequency of operation. The rate of twist and relationship of the pairs are contributing factors in

calculating the capacitive reactance of the cable. The higher the frequency, the more critical the capacitance becomes in controlling cross talk between pairs.

Within the telecommunications closet, patch cords should be constructed of stranded copper cable vice a solid conductor to increase their durability and their length limited to 6 m (20 ft.).

Caution: Eight-pin modular plugs for connecting to stranded cables differ from eight-pin modular plugs used for solid conductor wire because of the diameter of the wire. Station cords, also constructed of stranded cable, should be limited to a length of 3.1 m (10 ft.). These lengths may vary as long as the total length of horizontal patch cords does not exceed 9 m (30 ft.). Figure 13 illustrates the relationship between the station cords, horizontal distribution cable (telecommunications link), and the patch cords or cross connect wire which connect the closet end of the link to the system specific electronic equipment.

1.7.1 Installation. CAT 5 cable is usually packaged in 310 m (1000 ft.) rolls contained either on a spool or in a box. Several runs are usually pulled simultaneously. Extra care must be taken when uncoiling or unreeling CAT 5 cable to prevent kinking. A kink will adversely affect the capacitance and consequently the NEXT performance measurement. When kinked, the cable cannot be straightened out well enough to restore its original bandwidth properties and therefore must be replaced. Copper data and voice cable may be run simultaneously but should never share the same sheath or patch panel because of dissimilar power levels which could result in cross talk or equipment damage if mistakenly cross connected to the wrong system.

a) The minimum bend radius for fiber optic cable and 25 pair CAT 5 cable is 10 times the cable diameter. For CAT 3 UTP it is four times the cable diameter. Do not exceed a 90-degree bend.

b) Maximum pulling tension should not exceed 25 lb.

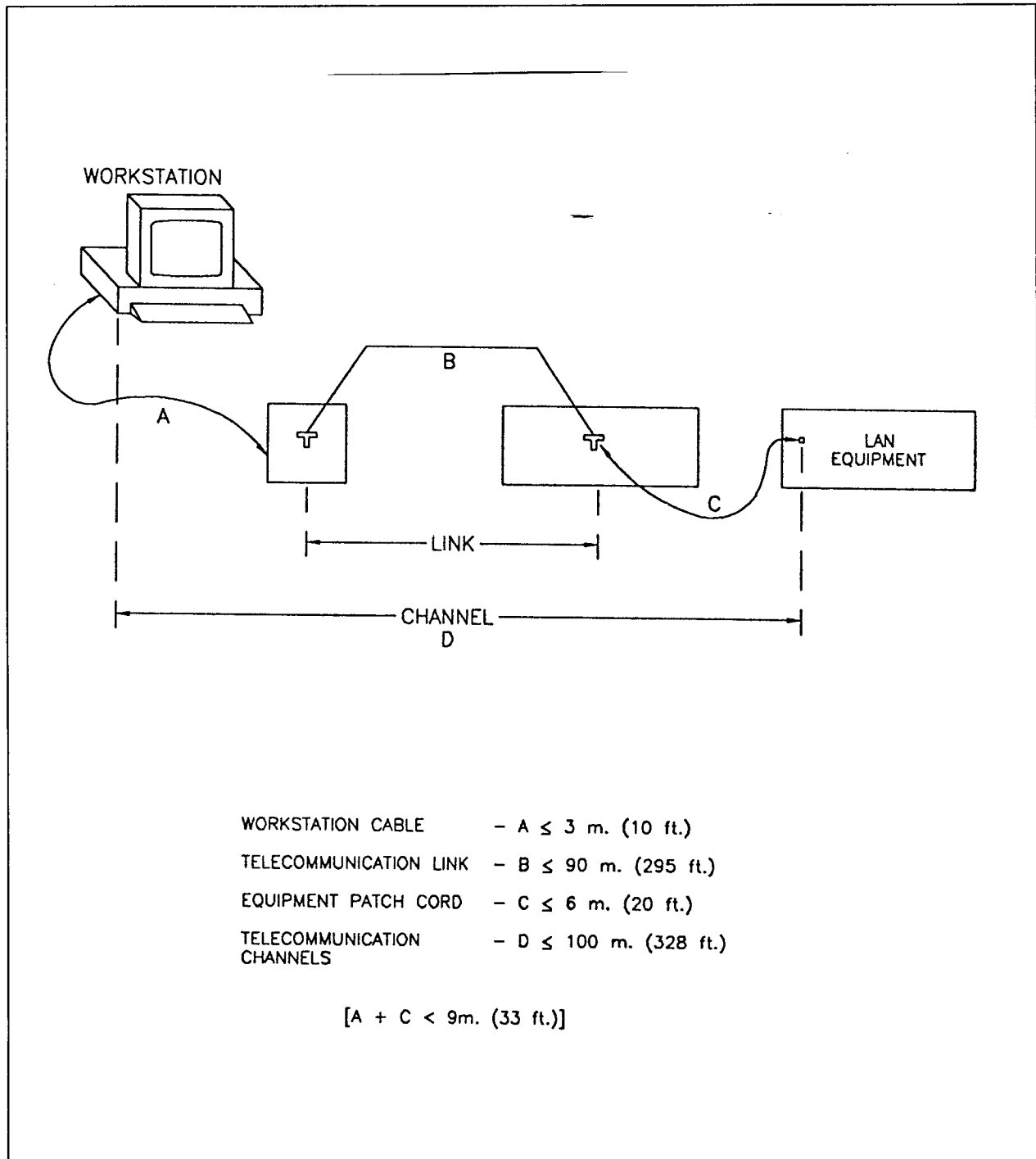
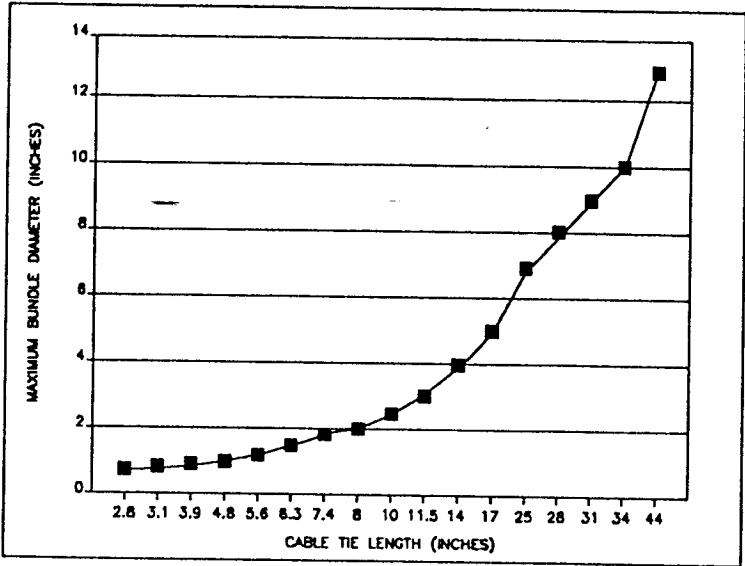


Figure 13
Horizontal Distances

c) Cable bundles should not be tightly wrapped or so large that the weight causes excessive stress on the bottom cables. The size of the bundles will normally be dependent upon the fill ratio of the duct being used or in the case of ceiling installations, ceiling bundles are usually limited to 55 when supported by 103 mm (4 in.) rings. Slack must be taken out of the bundles prior to wrapping them. Cable ties or wraps used in air plenums must be plenum rated. Cable wraps made of Velcro type material are available and help the installer avoid cinching cable bunches too tightly. Figure 14 illustrates how to determine the length of cable tie or wrap to use. Cables are to be homerun without the use of bridge taps which create multiple appearances. Bridge taps are expressly prohibited by FIPS 174. Cables installed in ceilings must maintain a 155 mm to 310 mm (6 in. to 12 in.) clearance above the false ceiling supports. Cables should be labeled at both ends in accordance with an approved cable management system as outlined in EIA/TIA 606, Administration Standard for the Telecommunications Infrastructure of Commercial Buildings. A convenient list of do's and don'ts for CAT 5 installation and termination, developed by the 504th Signal Battalion, is included as Appendix A.

1.7.2 Termination. Care must be taken during the termination phase to ensure that proper hardware and workmanship are applied to the effort. Never untwist CAT 5 cable more than 16 mm (1/2 in.) when terminating it. Installers require specific training and certification by a qualified instructor prior to attempting the termination of CAT 5 or fiber optic cables to maintain the integrity of the system design. Numerous manufacturers of CAT 5 cabling systems provide a 15-year warranty on their products but require that the installer be certified by that manufacturer as a qualified installer.

1.7.2.1 CAT 3 and 5 Terminations. The connecting hardware must be rated as high as the cable being installed. Insulation displacement type connectors should be used. The installation criteria for CAT 3 systems is identical to those specified for CAT 5 with the exception that CAT 3 cable may be untwisted 27 mm (1 in.) vice 16 mm (1/2 in.). Other practices should remain the same since it is likely that both categories will be pulled together and terminated in the same wall box to serve collocated voice and data jacks.



AWG/O.D. (in inches) STRANDED WIRE CHART					
AWG O.D.		AWG O.D.		AWG O.D.	
36	.006	22	.031	6	.184
34	.007	20	.038	4	.232
32	.008	18	.049	2	.292
30	.012	16	.060	1	.328
28	.015	14	.073	1/0	.368
27	.018	12	.096	2/0	.414
26	.021	10	.116	3/0	.464
24	.024	8	.147	4/0	.522

Figure 14
Cable Tie Length

EIA/TIA 568 identifies two authorized pin-outs for eight-pin modular jacks; 568A and 568B. FIPS 174 specifies that the 568A pin-out will be used. There are Government procurement contracts remaining in force that provide 568B pin-outs on their materials. Figure 15 provides 568A and 568B pin-outs. The pin-out pattern of the patch panel (568A or 568B) must match the pin-out pattern of the jack; if not connectivity will be disrupted (open pairs). The station end of the cable shall be punched down on the modular jack using the proper displacement tool to avoid damaging the cable insulation. At the telecommunications closet cables will be neatly routed to the patch panel and connected to the panel using the proper displacement tool.

1.7.2.2 Fiber Optic Terminations. The fiber optic 568SC connector is required for new construction projects. Activities currently using ST type connectors may continue doing so.

At the wall outlet a minimum of two fibers will be terminated in a 568SC duplex adapter. The fibers will be grouped in pairs and designated "A" and "B." The fibers are to be unidirectional, one send and one receive. At the far end the pair will be crossed-over. The fiber designated at the wall jack as "A" will be designated at the other end as "B." See Figure 6.

1.7.3 Testing. Testing shall be accomplished in accordance with EIA/TIA 568.

1.7.3.1 CAT 3 and 5 Testing. General tests for opens, shorts, grounds, and cable mapping (pin-out) shall be performed on UTP and shielded twisted pair (STP) cables. CAT 5 links shall be tested in accordance with EIA TSB-67, Field Testing of Unshielded Twisted-Pair Cabling Systems for attenuation and NEXT. The RCDD will review printed test results to ensure compliance with the applicable standard. Precise cable lengths may be measured using a time domain reflectometer (TDR).

1.7.3.2 Fiber Optic Testing. Fiber optic cables will be reel tested prior to installation. Reel testing consists of using a light source and meter, a launch cable, and mechanical splices. This test demonstrates continuity and loss associated with the fiber strands. The test technician will compare measurements with reel configuration data sheet provided by the manufacturer. Any anomalies (opens, kinks, etc.,) should result in rejection of the fiber optic cable prior to installation. Following installation each fiber strand shall be tested in one direction at either 850 nm or 1300 nm using a calibrated light source and

meter in accordance with Method B of EIA/TIA 526 14, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant. In accordance with EIA/TIA 568 a maximum loss of 2.0 dB is allowed for the fiber link which is defined as 90 m (295 ft.) of fiber and two connectors. Test results exceeding 2 dB shall be further tested using an optical time domain reflectometer (OTDR) to isolate the problem and correct the discrepancy.

1.8 Backbone Design. The most common function of a telecommunications backbone is to distribute voice/dial tone from a common switch to remote users and to connect data and video hubs to the network, via a bulk media path. Backbone design is applicable whenever or wherever multiple termination points require connectivity to a single location via an intermediate cross connect point. Backbone cabling is used to provide connectivity between buildings and floors, or, if a floor is of sufficient size, between multiple telecommunications closets on the same floor. Backbone connectivity is germane to both voice and data applications. NFPA 70, Articles 700 and 800 delineate requirements associated with the selection and installation of vertical backbone cabling. These articles address considerations such as cable housing and sheath print requirements, and miscellaneous support facilities. A primary function of these articles is to establish baseline requirements to prevent the spread of flame and smoke from floor to floor. A copper cable identified as a communications riser (CMR) in accordance with NFPA 70, Article 770, or a fiber optic cable with an optical fiber conductive (strength member) riser (OFCR) or optical fiber non-conductive (strength member) riser (OFNR) designation is suitable for use as a building vertical backbone cable. In addition to the determination of cabling schemes, the RCDD must also determine the physical support structure appropriate for implementing the backbone system.

1.8.1 Voice Backbone Cable Requirements. Utilization of a backbone system design will vary according to the type of signalling to be carried by the backbone. Because of the principal use of copper cable in voice applications, without multiplexing or other electronic interface, it is relatively easy to compute the size requirements for a backbone cable. Total the copper pair counts to each of the workstations to be serviced by the cable, increase the quantity by a factor of 50 percent, unless otherwise specified by the major claimant, and select the multipair cable which most closely meets or exceeds the pair count requirement. The standard multipair copper cable sizes available within the commercial industry are (pairs): 6, 12, 18, 25, 50, 75, 100, 150, 200, 300, 400, 600, 900, 1200, 1500, 1800, 2100, and 2400. Distribution of backbone cabling in large

multistory building and outside plant environments is generally sized in a tree topology as illustrated in Figure 16. Determination of cable sizing is initiated at the far end of the cable route and the backbone cable size increases as users are added en route to the point of origination, such as the telephone closet on the top floor of the building. When feasible, such as in smaller buildings, it is preferable to run dedicated backbone cables to each telecommunications closet without splicing.

Single mode fiber optic cable, which is specified for the outside backbone, will support trunking of voice circuits to the building either as inter-switch trunks or multiplexed lines.

1.8.2 Data Backbone Cable Requirements. The variety of data distribution media (UTP, STP, fiber optic, coaxial), network topologies, and data rates make determination of a data backbone system more complicated than for voice. The RCDD needs to closely coordinate with the claimant organization to determine what type of network topology and transmission media is required to meet the user's short-term (up to 3 years) and long-term (3 to 10 years) requirements. Topology requirements and distribution media selection are primarily driven by the electronics interface/systems selected by the claimant organization. In a new construction environment, where determination of claimant organization (or multiple organizations) requirements are not fully realized, the installation of multistrand (a minimum of 24 strands) fiber optic cable between each floor and the main distribution point should meet most short-term connectivity requirements. EIA/TIA 568, Section 5 defines the prevalent topologies used in the data community as the star and ring topologies (see Figure 16). IEEE 802.3, Information Technology - Local and Metropolitan Area Networks - Part 3: Carrier Sense Multiple Access With Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications and IEEE 802.5, Information Technology - Local and Metropolitan Area Networks - Part 5: Token Ring Access Method and Physical Layer Specifications further define data topologies. Backbone distribution for data connectivity is provided between the main distribution location and each telecommunication distribution closet or between buildings in the campus distribution environment. EIA/TIA-568, Figure 5-5 delineates distance limitations recommended for each of the distribution media types. UTP cable is not designed or recommended for inter-building backbone application. It is recommended that single mode fiber be used for inter-building backbone applications. When possible, for physical protection and administrative ease, it is recommended that separate voice and data backbone pathways be used. It is recommended that fiber optic cable be routed in an innerduct when backbone pathways must be shared. A single innerduct should never be pulled into an

empty duct. It will twist and preclude further use of the duct. Optimum fill ratio may be obtained by pulling three innerducts initially and leaving two empty with pull wire installed in each. A quadduct of uniconstruction duct may be substituted as appropriate.

1.8.3 Vertical Backbone Physical Support Structure. The vertical backbone physical support structure provides the means for routing backbone cables through a multistory building. Once the transmission media is selected, the RCDD must select an appropriately constructed cable to meet Federal and local fire codes. It is strongly recommended that new construction efforts incorporate telecommunication closets directly above each other to facilitate the most direct routing of vertical backbone cables and eliminate the need for conduit. The routing of vertical cables should not interfere with the installation of distribution backboards or equipment. Vertical backbone cable should not be routed through elevator shafts. It is recommended that vertical backbone cable not be routed through other building shafts which preclude direct access to the cable. If telecommunications closets on adjoining floors are not vertically aligned, horizontal routing will be required to interconnect them. A minimum of three 103 mm (4 in.) EMT conduits shall be provided as a cable pathway in accordance with EIA/TIA 569. Vertical access through floors and ceilings shall be accomplished by installing 103 mm(4 in.) conduit sleeves or cut slots. Conduit sleeves should, as a minimum, extend 1 in. above and below the floor and ceiling level. Conduits, vertical sleeves, and slots shall be firestopped in accordance with local building codes, American Society for Testing and Materials (ASTM) E814, Fire Tests of Through-Penetration Fire Stops, Underwriters' Laboratories Inc. (UL) 1479, Safety Fire Tests of Through-Penetration Firestops, and NFPA 70. The BICSI Manual, Telecommunications Cable and Pathway Design Parameters and Installation Practices and EIA/TIA 569 provide recommended sleeve quantities and slot sizes based on serviceable square footage of the building. These requirements are reiterated in Example Five. After selection of cable type, sizing, and routing has been accomplished, the RCDD must determine the best method of securing the backbone cable. Again, because there is a wide variety of available backbone cables, a variety of methods is necessary and acceptable for securing them. When determining the best method for securing a vertical cable, the RCDD must consider the following factors:

- a) Foot/pound and total weight of the cable;
- b) Shear strength characteristics of the cable sheath;

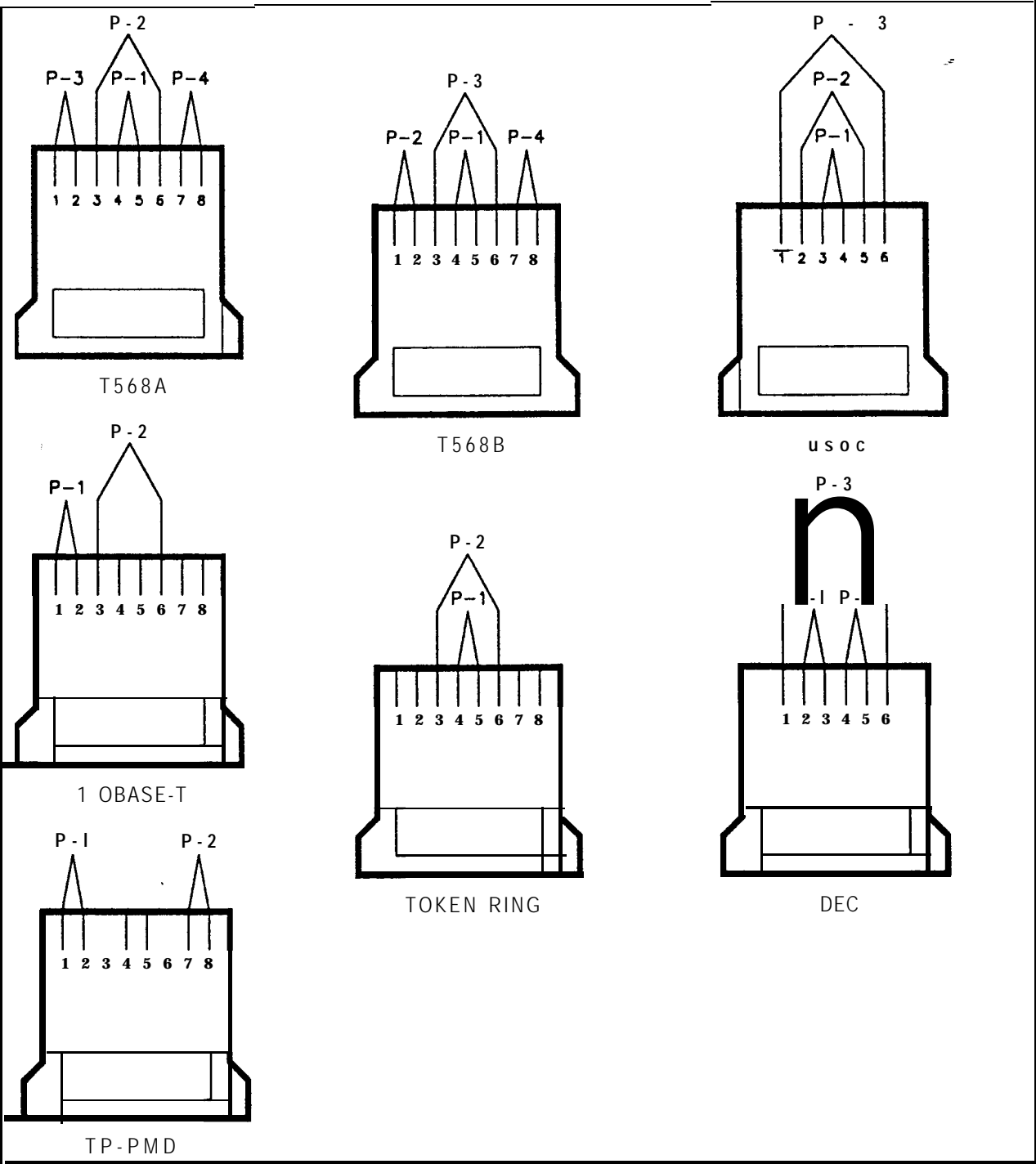


Figure 15
Modular Plug Pin-Out

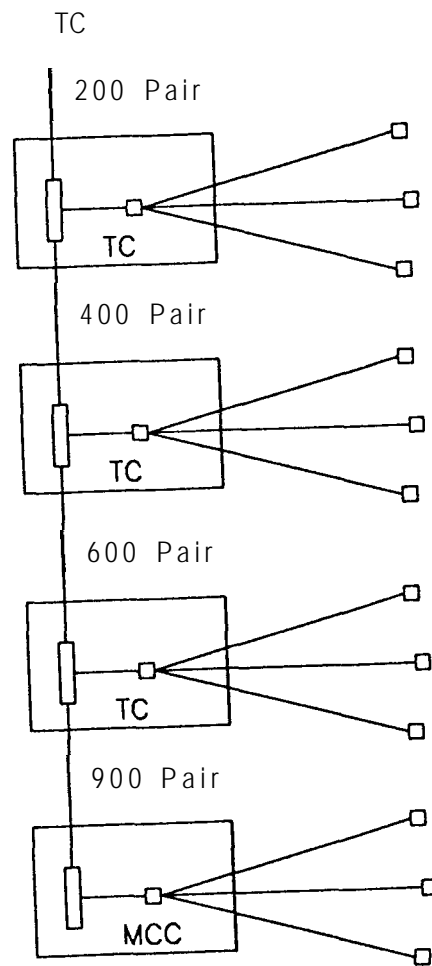


Figure 16
Tree Topology

c) Physical construction and load bearing characteristics of the building and walls (check with building architect or structural engineer); and

d) Bend radius.

Improperly installed vertical backbone cables can result in slippage of cable pairs within the sheath, stretching of copper wire, broken fiber, or even severe damage to the structural integrity of the building or walls. The most common method of securing a vertical cable is to use straps or clamps sized to meet the outside diameter measurement of the cable sheath. A minimum of three clamps or straps per floor is recommended. When selecting straps or clamps to be applied directly to a cable sheath, the RCDD should ensure that the clamp or strap is neither too loose, which can result in the cable sagging or cuts to the sheath or cable, or too tight, which can result in crimped cable pairs or broken fibers. Clamps and straps should be secured to a fire retardant plywood backboard or anchored to concrete/masonry walls in a manner which does not interfere with the horizontal distribution blocks or equipment in the telecommunications closet. When large heavy backbone cables are installed, use a steel support strand as a messenger cable. The American National Standards Institute (ANSI) C2, National Electrical Safety Code, Section 26, specifies that the minimum stress requirements of the messenger cable will not exceed 60 percent of rated breaking strength under load. In most instances, engineering of the messenger should not exceed 25 percent of the rated breaking strength under load. The cable should be tied or lashed to the messenger at intervals of 3 ft. The messenger can then be secured with ties to beam clamps, anchors, toggle bolts, or wall brackets. It is recommended that the RCDD obtain a registered structural engineer's approval prior to finalizing the installation method. When running fiber optic backbone cable vertically between floors in innerduct, the innerduct should be interrupted on alternating floors to secure the cable.

1.8.4 Campus Backbone Physical Support Structure. This handbook restricts the discussion of outside plant to the portion between the building and the serving manhole, pole, or building. The campus backbone physical support structure provides for routing, access, and protection of backbone cables between buildings. Backbone cabling of all media types can be routed between buildings by one of four methods: direct burial, underground, tunnel, and aerial. Relative cost comparisons associated with these methods are based on start-up costs and the assumption that there are no existing support structures.

EXAMPLE FIVE

DETERMINING VERTICAL BACKBONE PATHWAY
SLEEVE AND SLOT REQUIREMENTS

The number of 103 mm (4 ft.) sleeves or conduits and the size of slots required to support telecommunications related vertical backbone cables between floors may be determined using the table below:

Area Served Above	Number of 4 in. Sleeves
Less than 5,000 sq. m (50,000 sq. ft.)	3
5,000-10,000 sq. m (50,000-100,000 sq. ft.)	4
10,000-30,000 sq. m (100,000-300,000 sq. ft.)	5 - 8
30,000-50,000 sq. m (300,000-500,000 sq. ft.)	9 - 11
Area Served Above	Size of Slot
Less than 25,000 sq.m (250,000 sq. ft.)	155 mm x 243 mm (6 in. x 9 in.)
25,000-50,000 sq. m (250,000-500,000 sq. ft.)	155 mm x 465 mm (6 in. x 18 in.)
50,000-100,000 sq. m (500,000-1,000,000 sq. ft.)	243 mm x 540 mm (9 in X 20 in.)
100,000-140,000 sq. m (1,000,000-1,400,000 sq. ft.)	310 mm x 540 mm (12 in. x 20 in.)
140,000-200,000 sq. m (1,400,000-2,000,000 sq. ft.)	375 mm x 620 mm (15 in. x 24 in.)

1.8.4.1 Direct Burial. Direct burial cable is cable which is plowed into the ground or placed directly in a trench, usually 620 mm to 1240 mm (24 in. to 48 in.) below grade, or as specified by local codes. Selection of direct burial should be based on the volume of aboveground traffic in the area. The direct burial method is the least expensive of the four options. If an area is lightly travelled by pedestrian traffic, then direct buried cable is recommended as the least cost option. Direct burial of cable requires that the cable meet the manufacturing specifications of REA PE-39 or REA PE-89 for copper cable. These cables consist of a polyethylene sheath and are gel filled to prevent moisture access or buildup. These cables can be armored to protect them from rodent and gopher damage. Direct burial of fiber optic cable is not generally recommended but can be done if the cable is a tight buffered, loose tube, gel-filled cable with armor. The pathway for direct buried cable should be marked by two

methods. The first is by placing a conductive identification tape 155 mm to 243 mm (6 in. to 9 in.) below grade approximately 432 mm (16 in.) above the cable along the trenched route. Secondly, marker posts or flags should be placed aboveground along the trenched path at intervals not to exceed 78 m (250 ft.). The markers should also be placed at road crossings and bends. The next successive aboveground marker should be easily visible when viewed standing next to a marker. Splicing of direct buried cable may be accomplished aboveground in splice pedestals or in buried splice cases if reentry is not anticipated. Selection of splice pedestals should be based on cable sizes and types (refer to manufacturer recommendations for pedestal sizing). Direct buried cable is not recommended for areas with a high volume of motorized traffic such as parking lots or road crossings. Cable run under roads should be placed in either rigid galvanized or PVC Schedule 40 duct. EIA/TIA 569 and REA TE&CM 640, Buried Cable Plant Specification provide additional information for developing buried cable design. Cable segments between buildings or splice points should be measured using a distance wheel. Sufficient cable should be specified for splicing and termination at each end of each cable segment. A length of 3 m (10 ft.) at each end of the cable should provide sufficient slack for splicing or termination. When fiber optic cable is directly buried, a service loop of 8.3 m to 17 m (25 ft. to 50 ft.) should be provided at each end.

Warning: Personnel hazard. Prior to initiating any trenching or plowing for direct burial cable placement, the local Public Works Office, CATV company, and commercial Miss Utility must be notified 48 hours in advance to locate and identify other utility services located in the installation area. The other services can be in the form of gas lines, power cables, water lines, CATV lines, etc.

It can be advantageous to the RCDD and subsequent installation activity if the routing of other services within the area are identified and marked during the site survey process and again just prior to installation activity. Chapter 15 of the BICSI Manual provides recommended minimum space requirements between telecommunication cabling and utility services.

1.8.4.2 Underground

a) An underground cable support structure consists of the burial of conduit, manholes, and handholes for pathways between termination locations. An underground support structure provides the following advantages over other methods:

- (1) Increased physical protection of cable assets;
- (2) Reduced costs for follow-on cable installation efforts;
- (3) Reduced costs for reconfiguration and repair efforts; and
- (4) Improved area aesthetics as splices and junction points are hidden from casual observation.

b) Warning: Do not enter a manhole without complying with OSHA safety regulations. Code of Federal Regulations (CFR) Chapter XVII, Occupational Safety and Health Administration (OSHA) Labor Regulations, par. 1926.956 requires that prior to entering a manhole for inspection only:

- (1) Place a warning sign at the open manhole in accordance with PWC regulations;
- (2) Erect a barrier around the hole;
- (3) Test for explosive gases and adequate oxygen supply; force ventilate and retest as necessary.

c) This pathway is normally interconnected with manholes and handholes, for distances over 140 m (450 ft.), which provide en route access points for purposes of cable pulling, splicing, rerouting, and repair. Placement of manholes and handholes should not exceed 140 m (450 ft.) in any continuous run. Manholes and handholes should be positioned at distribution junction points or splice points along the pathway. Manholes should be configured with sufficient space to accommodate the duct (conduit) structure, cable racks, splice racks, corrosion resistant pulling eyes, earth ground, and a ladder. Manholes should have a sump 216 mm (8 in.) in diameter. Manhole sizes can vary and should be based on the number of conduits and cables entering it. As a minimum, a manhole should be 2 m long by 1.3 m wide by 2 m deep (6 ft. by 4 ft. by 6 ft.). Handholes should not exceed 1.3 m by 1 m by 1 m (4 ft. by 3 ft. by 3 ft.) and should not be used for cable splicing. The function of the handhole is to aid in the pulling of cable when the pull length of the cable requires two pulling segments or there are bends of more than 180 degrees. There should be no more than two 90-degree bends or a combination of bends exceeding 180 degrees in the conduit pathway between two manholes, two buildings, or a manhole and a building. The quantity of conduits between manholes, handholes, or buildings should be based on routing and interconnect considerations, cable types and sizes,

the conduit fill, and anticipated system growth. Par. 1.5.1.3.c) and EIA/TIA 569, Table 4.4-1 provides guidance for fill allowances of conduits. For new installations, a minimum of four 103 mm (4 in.) conduits between each building and the outside plant distribution system is recommended. Generally, the most common conduit selected for outside distribution is a PVC Type C (Schedule 40 or higher); however, other types of corrosion resistant conduit may be used (refer to EIA/TIA 569). Conduit runs should be placed 620 mm to 1240 mm (24 in. to 48 in.) below surface grade. Conduit entrances to manholes, handholes, and buildings shall provide for a drainage slope away from the building in accordance with EIA/TIA 569, par. 9.3.2.2.5, as shown in Figure 17. New conduit installations should be installed with a pull rope (polyrope or pull wire with a minimum pull strength of 200 lb) and a two-pair voice grade wire to facilitate electronic location of the duct prior to the installation of metallic cables. Conduits should be capped with approved, removable plastic caps or putty-type compound to prevent rodent access and water seepage into the duct. Do not route electric light or power circuit cabling in the same manhole or conduit distribution system as telecommunication, alarm, or fiber optic cabling. EIA/TIA 569, BICSI Manual, Chapter 2, and REA TE&CM 643, Underground Conduit and Manhole Design and Construction provide additional information.

d) Cable specified for an underground duct system should be the same as that identified in par. 1.8.4.1 above with the exception that armored inner sheathing is not required. It is strongly recommended that outside rated innerduct be installed prior to installing fiber optic cable in an underground system. Innerduct effectively and economically compartmentizes a larger support duct thus allowing the large duct to be used for additional or follow-on cable pulls without placing the fiber optic cable at risk due to shearing, friction tears, crimping and kinking, or breaks. Innerduct is of plastic manufacture and is available in a variety of sizes. Selection of the innerduct size should be based on the size of the main underground support structure conduit and the cables to be installed. Innerduct fill criteria is the same as conduit fill criteria and is defined in NFPA 70. Quadduct or three innerducts should be pulled in an empty duct prior to installing fiber optic or small copper cable. Cable segments between buildings or manholes should be measured using a distance wheel. In addition to the wheeled length measurements, sufficient cable should be specified for splicing and termination at each end of each cable segment and for racking in each manhole in the conduit pathway. In addition to the length required within the building to reach the entrance facility and the location of the protector terminals a length of

3 m (10 ft.) at each end of the cable will provide sufficient cable for sweeping bends, splicing, or termination. NFPA 70 prohibits running outside rated cable farther than 16.5 m (50 ft.) within a building unless it is in rigid conduit. Additional information regarding service entrances is included in par. 1.9.1. An additional cable length equal to 3/4 of the manhole perimeter measurement for each manhole in the pathway should be added to the overall cable segment length total. Since it is extremely difficult to ensure cable paths and reel lengths exactly, it is common practice to add 10 percent to the total cable estimate. When installing fiber optic cable, it is recommended that 8.2 m to 16.5 m (25 ft. to 50 ft.) of fiber cable be coiled in every other manhole along a pathway to provide slack for emergency repair splicing.

e) Warning: Prior to initiating any trenching or plowing for conduit placement, the local Public Works Office, CATV company, and commercial Miss Utility must be notified to identify and locate other utility services located in the installation area. The other services can be in the form of buried gas or water lines, power cables, CATV lines, etc. It can be advantageous to the RCDD and subsequent installation activity if the routing of other services within the area is identified and marked during the site survey process and again just prior to installation activity. Chapter 15 of the BICSI Manual provides recommended minimum space requirements between telecommunication cabling and utility services.

1.8.4.3 Tunnel. The criteria for the type, size of cable, and mechanical placement requirements of backbone cabling in a tunnel is similar to that identified in the underground system described in par. 1.8.4.2 above. The engineering and estimating factors to be considered when routing backbone cable through a tunnel are:

a) Physical separation between backbone cables and high or low voltage power cables must be at least 310 mm (12 in.) parallel, 103 mm (4 in.) crossing;

b) Physical separation between backbone cables and water, steam, or gas piping shall be at least 310 mm (12 in.) parallel and 155 mm (6 in.) crossing;

c) Racking methods and techniques for cable routing and splice cases;

d) Tunnel access for personnel and material, crossing points and corners;

e) Requirements for conduits;

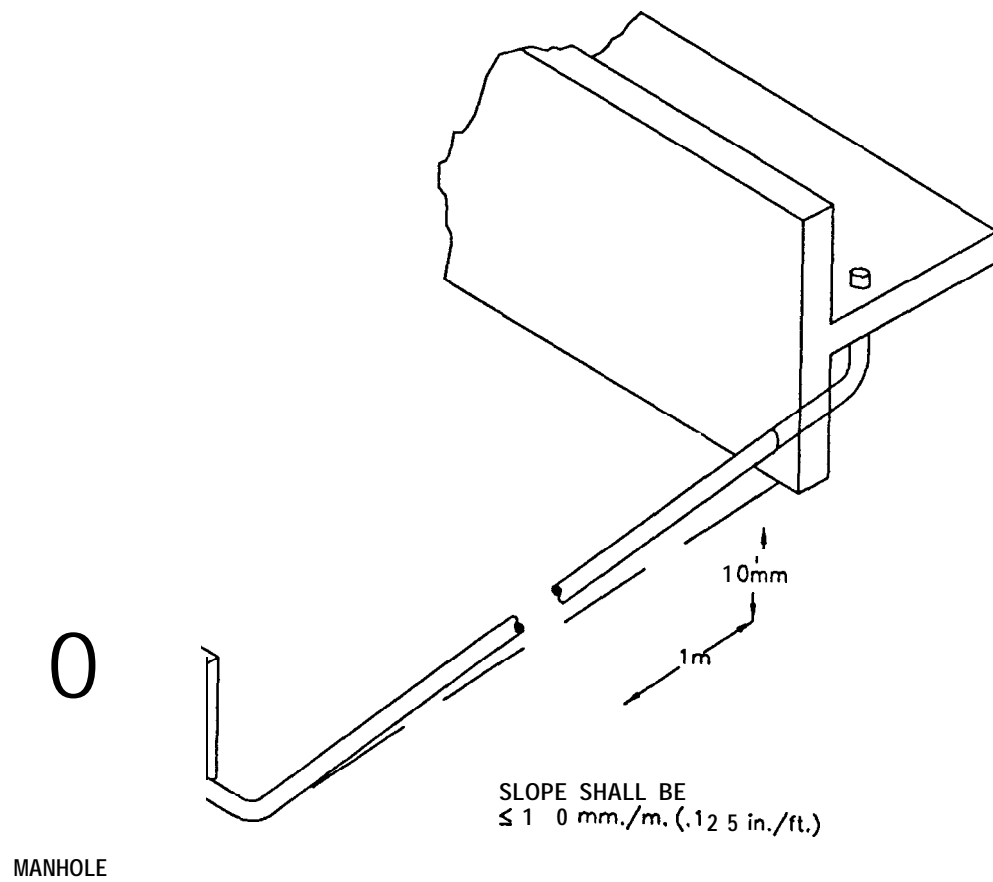


Figure 17
Entrance Duct Drainage

f) Year round access; and

g) The presence of asbestos on utility service pipes

If conduit is installed in a tunnel as a pathway for backbone cabling factors such as fill ratio and pull/splice points must be addressed. Limitations on lengths, bends, and separations are delineated in NFPA 70. EIA/TIA 569 and EIA/TIA 472B, Fiber Optic Communication Cables for Underground and Buried Use provide information regarding placement of backbone cables in the tunnel environment.

1.8.4.4 Aerial

a) The aerial backbone support structure is the least desirable method for routing cables between buildings because of the following considerations:

(1) High initial costs associated with pole placement;

(2) Subject to damage because of extreme environmental conditions;

(3) Subject to damage because of casual negligence;

(4) Higher maintenance requirements versus other methods;

(5) Poor aesthetic quality; and

(6) The installation of aerial utilities is usually prohibited on facilities where airfields or helicopter pads are located.

b) If aerial routing of a backbone cable is the only method available or use of an existing pole line is directed by the cognizant authority, the RCDD must consider several factors. These factors include:

(1) Vertical clearance to the grade surface;

(2) Existing fill of the pole line by type, quantity, and services of other cables on poles;

(3) Separation clearances from other cables on poles;

- (4) Span lengths should not to exceed 33 m (100);
- (5) Material condition of existing poles;
- (6) Guying requirements; and
- (7) Building attachments and service entry.

c) When routing backbone cable over an aerial pathway, the RCDD must account for a wide range of vertical clearances. Telecommunication cable clearances as established in NFPA 70 are:

- (1) 1.01 m (40 in.) below power cables at the power pole;
- (2) .305 m (12 in.) below power cables at mid-span under sag conditions;
- (3) .103 m (4 in.) horizontally at building attachment;
- (4) .305 m (12 in.) vertically at building attachment;
- (5) 5.5 m (18 ft.) vertically above a street or driveway, higher if normal vehicle traffic exceeds this height;
- (6) 3 m (9.5 ft.) above pedestrian traffic;
- (7) 2.44 m (8 ft.) above crossed rooftops;
- (8) 8.23 m (27 ft.) above railroad tracks; and
- (9) 1.83 m (6 ft.) parallel to rooftop conductors such as antennas, etc.

d) It is necessary to ensure that poles to be used in the aerial pathway are materially sound enough to support the installation size and physical support requirements. As new cables are added to pole lines, additional guy wires are required at each turn and at the beginning and end poles to ensure proper balancing of pathway stress points. Copper cable selected for placement on aerial pathways should be manufactured to REA PE-22 or REA PE-38, Self Supporting Cable standards. Fiber optic cable should be tight buffered, loose tube with an outside sheath manufactured to withstand continued exposure to ultraviolet light deterioration. Installation of copper cable over 100 pair should be installed on separate support strands. Fiber optic cable and copper cable under 100 pair can be installed with individual

support strands or may be lashed to existing cables if the poles and strands are rated to support additional cable weight. When installing fiber optic cable, service loops of 8.2 m to 17 m (25 ft. to 50 ft.) should be placed every 100 m (300 ft.) along the pole line. Aerial support structure engineering, design, and construction information can be obtained from EIA/TIA 569, BICSI Manual, Chapters 2 and 21, and the following REA TE&CMs; 602, Clearances, 605, Right of Way Clearances, 611, Pole Lines, 626, Staking, 630, Design of Overhead Lines, and 635, Construction of Overhead Lines.

1.9 Equipment Room and Entrance Facility. Equipment room is the designation given to the specific telecommunications closet where the building's telecommunications, e.g., PBX, computing, main cross connects, and video equipment are located. See Figure 18. The entrance facility of a building represents the transition point between the external distribution backbone and the building distribution system and is the point where outside cables coming from the service entrance are terminated and protected. In many instances the two functions may be incorporated within the same room. The design elements for each room are basically the same. For the purposes of this handbook, the term "equipment room" has been selected to represent the design elements for both functions. The equipment room should be of sufficient size to accommodate cable distribution points such as backboards, terminal blocks, fiber optic distribution centers, splice cases, etc., electronic interface equipment, digital switching system (DSS), fiber optic interface/transmission equipment, LAN bridges, routers, multiple access units, etc., line interface units (LIUs), channel banks, and multiplexing equipment as required. The equipment room can be a mixture of individual or integrated functions necessary to provide information support services to the building. The critical design elements associated with an equipment room are: location, size, physical layout, power, isolated ground, and environmental conditioning. Size entrance ducts are shown in Example Six.

EXAMPLE SIX

DETERMINING ENTRANCE DUCT REQUIREMENTS

Entrance ducts to support buried or underground cables entering a building should never be less than 103 mm (4 in.) in diameter. Having determined the size of the copper entrance cable or cables, determine the outside diameters of the cables by consulting a manufacturer or authorized dealer. Duct fill ratios should be in accordance with NFPA 70 as restated in par.

1.5.1.3.c). Use the table below to determine number of entrance ducts required for the size of copper cables being installed. An additional duct for fiber optic cables and one spare duct for future telecommunications use should be added to the number of entrance ducts required for copper cable to determine minimum number of telecommunications ducts required. Provide telecommunications duct requirements to the electrical estimator.

Number of Copper Pairs	Number of 103 mm (4 in.) Copper	Ducts for: Fiber	Ducts for: Spare
Less than 1000	1	1	1
1000 - 2000	2	1	1
2000 - 3000	3	1	1
3000 - 5000	4	1	1
5000 - 7000	5	1	1
7000 - 9000	6	1	1

1.9.1 Equipment Room Location

a) Selection of the equipment room location is critical to the successful implementation of a functional telecommunications distribution design. The equipment room should be located as close as possible to the cable service entrance point and the vertical distribution pathways. Cables entering the building via the service entrance are rated for outside use and are not low-smoke rated cables. As such they are limited by NFPA 70 to a length of 50 ft. within the building unless run in rigid conduit. The cable sheath is to be grounded as soon as possible upon entering the building to reduce the spread of lightning-induced currents within the building. Copper cables are to be terminated in the entrance facility on a composite gas and heat coil protector.

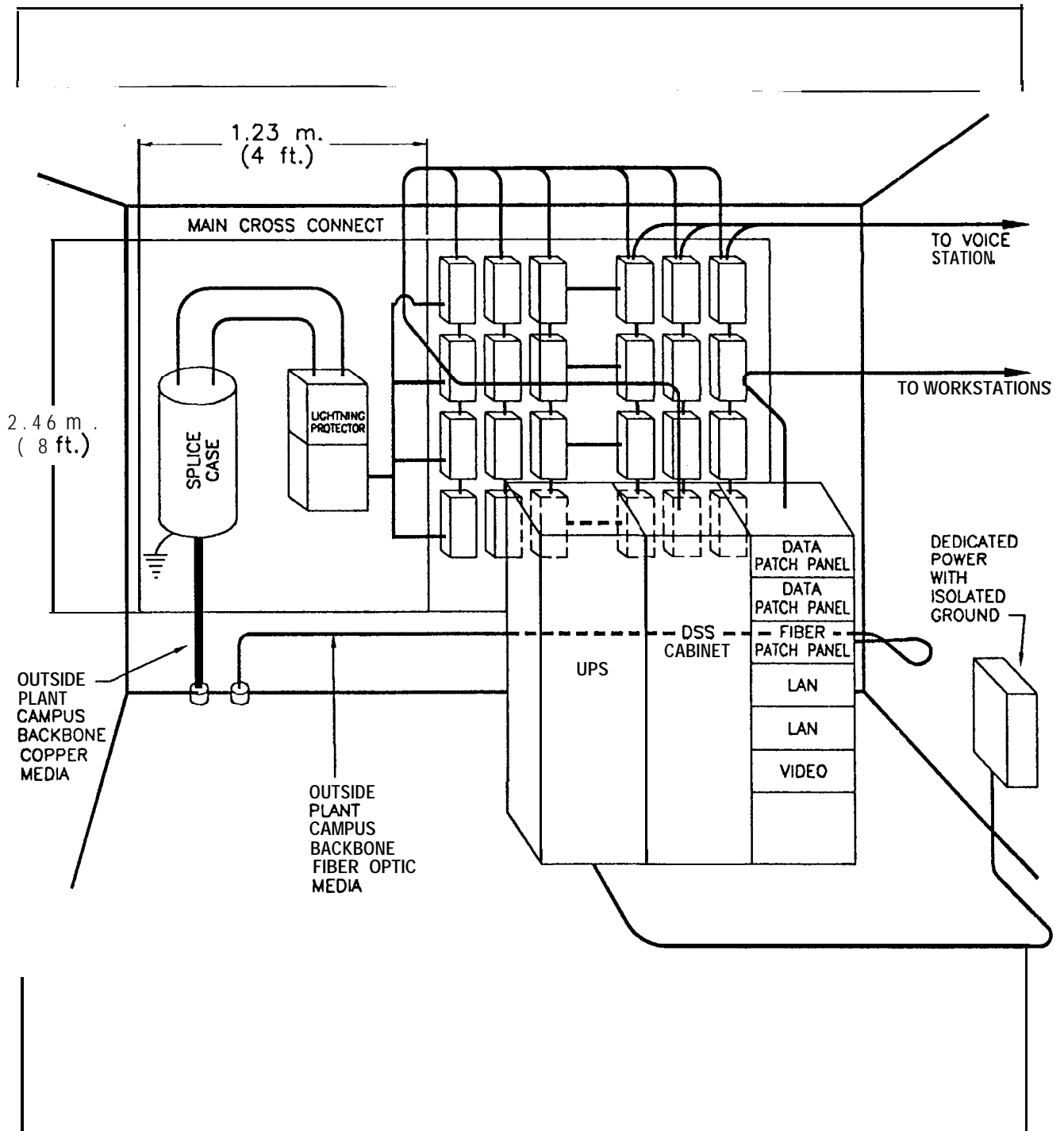


Figure 18
Equipment Room

b) The equipment room should also have continuous HVAC sized to accommodate the equipment installed and must have access to adequate electrical service. EIA/TIA 569 recommends that buildings having 2000 sq. m (20,000 sq. ft.) or greater of usable floor space, should have a designated equipment room. When there is less than 2000 sq. m (20,000 sq. ft.) of usable floor space a dedicated closet may suffice. The final determination should be based on the connectivity and hardware requirements of the building and its tenants. When determining the location of the equipment room EIA/TIA 569 recommends consideration be given to the following factors:

(1) Area must be free of potential water infiltration. Avoid boiler rooms, washrooms, janitor's closets, area below bathrooms, spaces with steam pipes, drains, etc.;

(2) Avoid areas which will restrict expansion or growth of the facility;

(3) Avoid areas which include, or are adjacent to, high vibration or excessively noisy equipment;

(4) Do not allow the selected space be used as a storage area for items not directly associated with the function of the space (cleaning supplies, paper products, grounds-keeping equipment and material, combustible dust, or fuels); and

(5) Avoid spaces collocated with or adjacent to equipment with high EMI ratings, such as elevators, door openers, copiers, transformers, industrial equipment, etc.

c) The equipment room must provide adequate floor space to support the initial installation of new systems and be capable of managed growth over the useful life of the building. To properly size an equipment room, the RCDD must obtain a detailed listing of space requirements for equipment, support materials, backboards, terminal blocks, various environmental, security, and fire alarm panels and administrative and maintenance functions that the claimant organization(s) or equipment vendors intend to locate in the equipment room. This listing must identify the physical requirements of the equipment such as dimensions, weight, power requirements, heat dissipation (in Btu's), installation methods, whether wall mount, floor cabinets, or racks, and OSHA and NFPA 70 egress and personnel work clearances. The environmental information and dimensions are readily obtainable from the manufacturer or suppliers of the equipment.

d) EIA/TIA 569, Table 8.2-2, stipulates a minimum 15 sq. m (150 sq. ft.) for an equipment room for buildings with up to 100 terminals or stations. This figure is adjustable to customize requirements. EIA/TIA 569, Table 9.5-2 offers minimum equipment room size recommendations based on building gross square footage. Each of these tables provides suggested minimums and it is incumbent upon the RCDD to ensure sufficient space is made available for the equipment room to meet the initial and growth requirements of the building. Room ceiling clearance, without obstructions, should be a minimum of 2.7 m (8 ft.). Floor planning (equipment and material placement within the room) should be premised on two elements. The first establishes the collocation of integrated or like functions of equipment or systems installed in the room. The second element considers cable ingress and egress signal flow. Distribution planning should minimize cable lengths and crossovers of interconnecting cables within the room.

1.9.2 Equipment Room Supplementary Design Considerations. Structuring an equipment room involves more than floor planning and space allocation. It includes details such as room access via double doors for equipment and installation material, access to building services, e.g., elevators, hallways and loading docks, lighting, fire protection, physical and electronic security, HVAC, electrical requirements, and structural considerations.

1.9.2.1 Access. Doors to an equipment room should be a minimum 1 m (36 in.) wide, 2.5 m (80 in.) high, lockable, and open outward. If possible, a double door entry point is recommended. It is important to have ready access from the equipment room to service elevators, loading docks, and hallways to facilitate the transportation of heavy equipment, cabinets, and racks to the room during initial and add-on installations.

1.9.2.2 Lighting. EIA/TIA 569, recommends a minimum lighting specification of 540 lm (50 footcandles) measured at 1 m (3 ft.) AFF. Lighting should be controlled by one or more switches located next to entry and exit door(s) to the room and equipped with occupancy sensors if not manned full time. Positioning of lighting fixtures should be no less than 2.7 m (8 ft.) above the floor and configured to provide maximum light coverage to work areas around equipment cabinets or racks. Too often light fixture positioning provides the requisite light coverage for an empty room and when cabinets or racks are installed the light coverage is reduced. The RCDD needs to provide equipment layout information to the facility design engineer(s) to ensure adequate

light coverage of working areas. Emergency lighting and exit signs should be installed to accommodate emergency egress from the room.

1.9.2.3 Fire and Security. Fire protection should be in accordance with local codes. As a minimum, at least two CO₂ or dry chemical portable fire extinguishers should be located in the room. One should be located near the entry and exit doors and the other near a high traffic area in the room. Physical security of the space should include lockable doors. Additional security considerations such as key card or cipher lock entry should be at the discretion of the claimant organization. Refer to MIL-HDBK-1008B, Fire Protection for Facilities Engineering, Design and Construction for fire protection requirements.

1.9.3 Equipment Room Environmental Considerations. The equipment room should be environmentally stable 24 hours a day, 365 days a year. The RCDD is not usually required to develop detailed engineering design or installation cost estimates for electrical or HVAC services. The RCDD should, however, provide the equipment and room requirements to the electrical and HVAC engineers for inclusion in the overall service design. The equipment specification and configuration data established by par. 1.8.5.2 must be provided to the HVAC and electrical engineers to ensure adequate sizing of air handling or heating units and power availability. Temperature and humidity controls should be located within the equipment room. In most cases, equipment specifications will identify environmental requirements for optimum performance results. However, if individual equipment or systems data is not available then EIA/TIA 569, par. 8.2.3.6 suggests the following standards:

Temperature Range: Low - 18 degrees C/64 degrees F
High - 24 degrees C/75 degrees F

Humidity Range: Low - 30 percent
High - 55 percent

Ambient temperature and humidity measurements should be performed at a level of 1.7 m (5 ft.) above the floor, along a centerline between equipment, and with all equipment operating. If batteries are required, ensure adequate ventilation in accordance with OSHA regulations and local codes.

1.9.4 Equipment Room Electrical Considerations. The equipment room should be provided with its own electrical service panel and isolated ground. When backup power is available within the building, a separate service panel connected to the backup power should be provided in the equipment room. Electrical

distribution panel sizing is based on amperage service and circuit breaker quantity. The RCDD should ensure electrical service panels are sized to provide for expansion of the equipment room service by specifying a minimum oversizing of 50 percent (e.g., if the baseline electrical requirements are 100 amperes and 24 circuit breakers, specify 150 amperes and 36 circuit breakers). If it is within budget and building service availability, 100 percent oversizing is preferable. Each equipment cabinet or rack should be assigned its own circuit breaker rated to meet the current load of the equipment within the cabinet. Each cabinet should be labeled front and back with the panel number and the circuit breaker assignment. Power strips, with sufficient outlets to accommodate the equipment assigned plus two for portable test equipment and tools, should be installed in the cabinet. In addition to the outlets available within the equipment cabinets, dual receptacle wall outlets should be placed around the room. NFPA 70, Section 210-52 and EIA/TIA 569, par. 9.5.5.6.1 establish a minimum of 1.83 m (6 ft.) between receptacles. Wall outlets should be placed 155 mm (6 in.) above the floor. At least one wall outlet should be connected to the backup power service panel if available. It is recommended that backup power facilities (generators, uninterruptible power supply (UPS), etc.,) be provisioned with an automatic switching and filtering capability to preclude loss of service or transient damage to the electronic equipment.

1.9.5 Equipment Room Structural Considerations. The multitude of installation options for electronic equipment and cable routing in an equipment room require the RCDD to ensure the room will structurally accommodate most installation practices. Structural considerations consist of floor type, wall mounting, and interior cable management support.

1.9.5.1 Flooring. Two primary types of flooring are used in equipment rooms: access floors and concrete floors which are usually either covered with antistatic tile or painted. Details regarding access flooring are described in par. 1.5.1.1.f) of this handbook. Determining the selection of the floor type is dependent upon several factors. The first element to be considered is the volume and flexibility requirements of the cabling to be routed within the room. If the claimant anticipates extensive growth of systems over the life cycle of the room, or the probability of routine access to the cable pathways is high, then it is recommended that an access floor be used. Information affecting load bearing computations for the equipment, cabinets, and cable should be provided to the structural engineer for inclusion in new building design. When an equipment room is being planned for a renovated building, the

RCDD should verify floor loading capacities with the structural engineer. EIA/TIA 569 recommends 250 lb/sq. ft. for distributed weight load and 1000 lb/sq. ft. for concentrated load. Carpeting for access floor covers or concrete floors is not recommended because of the potential for dust and static buildup.

1.9.5.2 Walls. Equipment room walls should be concrete or drywall mounted to 103 mm (4 in.) studs. To support wall-mounted electronic equipment or cable management systems (termination blocks, D rings, etc.,) an A-C plywood backboard must be mounted to the wall. The backboard should be a minimum 21 mm (3/4 in.) thick. It should be attached to walls with 10 mm by 78 mm (3/8 in. by 3 in.) toggle bolts or 10 mm (3/8 in.) drop-in anchors with 10 mm by 388 mm (3/8 in. by 1-1/4 in.) bolts with fender washers. The plywood should be painted with two coats of light colored fire retardant paint. Care should be taken not to paint over the fire rating stamp. EIA/ TIA 569 recommends a minimum of two walls be covered with plywood 8 feet high. EIA/TIA 569, Table 9.5-1 provides minimum recommended wall space based on building gross floor space. For equipment rooms occupied by personnel for extended periods on a daily basis, provision of a sound absorbing wall covering should be considered. Wall colors should be light in color and hue to enhance room lighting.

1.9.5.3 Cable Management Support. The volume and types of cables to be routed within an equipment room significantly affect the RCDD's selection of cable management support structures. Almost all the various methods for cable routing within the building (tray, access floors, wall mounting, etc.,) are applicable to the equipment room. Descriptions of the various methods are provided in par. 1.5 of this handbook. The equipment room must accommodate vertical, horizontal, and external backbone and distribution cables and support structures. It is recommended that like cables be grouped by function, voice, data, and fiber optic. When it is cost prohibitive to install an access floor, the room should have a matrixed tray distribution design to ensure maximum flexibility of cable routing in an organized manner.

1.10 Telecommunications Grounding and Protection. The RCDD is also responsible for designing the single-point ground system within and between the telecommunications closets in accordance with EIA/TIA 607. The variety of grounding requirements associated with the installation of a telecommunications system within a building are founded on two principles. The first is to provide personnel and equipment protection from electrical surges or transient voltages due to external sources such as lightning, equipment failures, shorts, power inductance, etc. The second

reason for the application of grounding principles is to reduce the effect of EMI and radio frequency interference (RFI). NFPA 70, Section 800, EIA/TIA 569, BICSI Manual, Chapter 6, FM11-490-9, MIL-HDBK-232, and MIL-HDBK-419, Grounding, Bonding, and Shielding for Electronic Equipments and Facilities Applications delineate the methodologies and requirements for grounding of cable, conduit, tray, cabinets, and the building structure. Extensive requirements are associated with developing a facility ground system. The RCDD, while not usually required to develop the detailed building ground system design, should be well versed in the requirements of the referenced guidance instructions and be prepared to offer assistance to ensure the most effective communications grounding system is made available. As discussed in par. 1.9.1, conductive cables entering a building must have their shields grounded and be provided fused protection, or be connected via an insulated joint, as close to the service entrance as possible. This is generally accomplished through the use of protectors as qualified by UL 497, Safety Protectors for Paired Conductor Communication Circuits (primary), and UL 497A, Safety Secondary Protectors for Communication Circuits (secondary). Equipment cabinets, trays, conduit, duct, etc., shall be bonded together with ground leads connected directly to the building ground or the electrical panel ground, whichever is closer. Connection via a 6 AWG wire is recommended. Bonding shall be accomplished using approved bonding methods for the application. It is recommended that copper buss be provided in equipment cabinets and power panels to facilitate the grounding and bonding of telecommunication equipment and cables. In manholes, splice cases, and other metal items are to be bonded to a ground rod driven a minimum 6 ft. into the ground. In areas where cable may be exposed to lightning strike, particularly aerial cable, a separate lightning rod with independent ground pathway will be installed and located at least 2 m (6 ft.) from the cable or cable entry point to the building.

The transfer rate, or operating speed, of telecommunication accelerates with each passing year. As these data rates increase, they become more susceptible to EMI and RFI. To help reduce the effect of EMI and RFI, it is recommended that exposed cables be specified to include shielding and a drain wire. An exposed cable is defined as a cable which may be subjected to lightning, power crosses, power induction, or differences in ground potential. A cable shield is a metallic covering of an insulated conductor, cable core, or group of conductors within a cable core. A drain wire is a non-insulated wire located within a cable sheath and adjacent to the shield or

screen. The drain wire makes grounding and bonding of the shields easier. Shields and drain wires shall be bonded together in splices and to the building grounds at each end of the cable.

To minimize the possibility that electronic equipment located on various floors may be operating at different ground potentials, a single point ground system shall be established. A separate copper ground cable, 6 AWG or larger, as specified by EIA/TIA 607, shall be run adjacent to the vertical copper backbone cables and extended to each telecommunications closet where it shall be terminated on a bus bar. The bus bar shall also be connected to structural ground where possible. Within each closet, racks and cabinets shall be connected to the bus bar. At the entrance room the single point ground cable shall be grounded by extending the cable (system ground) within a 16 mm (1/2 in.) EMT conduit to the main electrical panel and connecting the cable to the panel ground (service entrance ground). Do not connect to the neutral conductor.

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APPENDIX A
DO'S AND DON'TS OF CATEGORY (CAT) 5 CABLING

DO:

1. Store the cable in a protected, moisture-free area.
2. Avoid unnecessary bends.
3. Replace damaged cable.
4. Make all connections via patch panels or cross connect blocks.
5. Use insulation displacement type connections. These can be M66 or 110 type but must be certified to meet CAT 5 specifications.
6. Use the same manufacturer's cable throughout.
7. Do not cinch cable ties tightly. Use Velcro straps, D rings or similar mechanical devices to support the cables within the closet area.
8. Do not mix power and telecommunications in the same tray without insulated separators.
9. Label cables on both ends in accordance with EIA/TIA 606.
10. Avoid sources of heat.
11. Avoid sources of EMI.
12. Maintain a 6-in. separation from fluorescent lighting.
13. Maintain the same TIA pin-out on cables throughout the system.
14. Comply with EIA/TIA 568 CAT 5 termination practices, especially the maintenance of the factory twist on each pair to within 1/2 in. of the termination point.
15. Follow Environmental Protection Agency (EPA), building, and fire codes. Firestop penetrations.

APPENDIX A (Continued)

DO NOT:

1. Step on or kink the cable.
2. Exceed the maximum tensile loading (pulling tension) of 25 lb during cable placement.
3. Overstress the cable.
4. Exceed the bend radius or bend the cable beyond a 90-degree angle on turns.
5. Use staples for securing cables.
6. Overtighten cables ties or cords.
7. Route cables near EMI noise sources, such as motors, fluorescent lights, or power lines.
8. Run telecommunications cables in raceways with power.
9. Mix cables from different manufacturers in the same circuit.
10. Use a component rated below CAT 5.
11. Use screw-type terminations.
12. Splice, bridge tap, or otherwise attempt to repair cable.
13. Exceed the maximum cable length of 100 m (328 ft.) for the CAT 5 telecommunications channel, comprised of the patch cord, workstation cord, and horizontal link, as specified in EIA/TIA 568.

REFERENCES

NOTE: THE FOLLOWING REFERENCED DOCUMENTS FORM A PART OF THIS HANDBOOK TO THE EXTENT SPECIFIED HEREIN. USERS OF THIS HANDBOOK SHOULD REFER TO THE LATEST REVISIONS OF CITED DOCUMENTS UNLESS OTHERWISE DIRECTED.

FEDERAL/MILITARY SPECIFICATIONS, STANDARDS, BULLETINS, HANDBOOKS, AND NAVFAC GUIDE SPECIFICATIONS:

Unless otherwise indicated, copies are available from the Naval Publishing and Printing Service Office (NPPSO), Standardization Document Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

HANDBOOKS

MIL-HDBK-232	RED/BLACK Engineering - Installation Guidelines.
MIL-HDBK-419	Grounding, Bonding, and Shielding for Electronic Equipments and Facilities Applications.
MIL-HDBK-420	Site Survey Handbook for Telecommunications Facilities.
MIL-HDBK-1008B	Fire Protection for Facilities Engineering, Design and Construction.
MIL-HDBK-1035	Family Housing.
MIL-HDBK-1036	Bachelor Quarters.
MIL-HDBK-1190	Facility Planning and Design Guide.
MIL-HDBK-1191	Medical and Dental Treatment Facilities Design and Construction Criteria, Department of Defense

OTHER GOVERNMENT DOCUMENTS AND PUBLICATIONS:

DCI 1/21	Physical Security Standards for Sensitive Compartmented Information Facilities.
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(Unless otherwise indicated, copies available from Central Intelligence Agency (CIA), Washington, DC 20505.)

FIPS-PUB-174 Federal Building Telecommunications
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(Unless otherwise indicated, copies are available from U.S.
Department of Commerce, Gaithersburg, MD 20899.)

NAVELEX 0101/102 Naval Shore Electronics Criteria,
NCS Design, Chapter 12, Communications
Electronic Grounding.

NACSIM 5203 Guidelines for Facility Design and RED/
BLACK Installation.

(Unless otherwise indicated, copies are available from Naval
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(Unless otherwise indicated, copies are available from U.S. Army
Publications Distribution Center, 1655 Woodson Road, St. Louis,
MO 63114.)

NON-GOVERNMENT PUBLICATIONS:

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C2 National Electrical Safety Code.

(Unless otherwise indicated, copies are available from American
National Standards Institute (ANSI), 11 W. 42nd Street, New York,
New York 10036.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E814 Fire Tests of Through-Penetration
Fire Stops.

(Unless otherwise indicated, copies are available from American
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BUILDING INDUSTRY CONSULTANT SERVICES INTERNATIONAL (BICSI)

BICSI Telecommunications Distribution Methods (TDM) Manual
Telecommunications Cable and Pathway Design Parameters and
Installation Practices.

(Unless otherwise indicated, copies are available from Building
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EIA/TIA 472B	Fiber Optic Communication Cables for Underground and Buried Use.
EIA/TIA 526	Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.
EIA/TIA 568	Commercial Building Telecommunications Cabling Standard.
EIA/TIA 569	Pathways and Spaces.
EIA/TIA 570	Residential and Light Commercial Telecommunications Wiring Standard.
EIA/TIA 606	Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.
EIA/TIA 607	Commercial Building Grounding and Bonding Requirements for Telecommunications.
EIA TSB-67	Field Testing of Unshielded Twisted- Pair Cabling Systems.
EIA TSB-72	Centralized Optical Fiber Cabling Guidelines.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC. (IEEE)

IEEE 802.3	Information Technology - Local and Metropolitan Area Networks - Part 3: Carrier Sense Multiple Access With Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.
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IEEE 802.5 Information Technology - Local and
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Arlington, VA 22209.)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 National Electrical Code.

NFPA 262 Fire and Smoke Characteristics of Wires and
Cables.

(Unless otherwise indicated, copies are available from National Fire
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REA PE-22 Specification for Aerial and Underground
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REA TE&CM, Section 602, Clearances.

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(Unless otherwise indicated, copies are available from Rural Electrification Administration (REA), Department of Agriculture, 14th and Independence Avenue, S.W., Washington, DC 20250.)

UNDERWRITERS LABORATORIES, INC. (UL)

UL 497	Safety Protectors for Paired Conductor Communication Circuits.
UL 497A	Safety Secondary Protectors for Communication Circuits.
UL 1479	Safety Fire Tests of Through-Penetration Firestops.
UL 1666	Flame Propagation Height of Electrical and Optical Fiber Cables Installed Vertically in Shafts.

(Unless otherwise indicated, copies are available from Underwriters Laboratories, Inc. (UL), 333 Pfingsten Road, Northbrook, IL 60062.)

GLOSSARY

ACRONYMS

AEI. Architectural engineering instructions.

AFF. Above the finished floor.

ATM. Asynchronous transfer mode.

BALUN. Balanced/unbalanced.

BICSI. Building Industry Consultant Services International.

BQ. Bachelor quarters.

CATV. Cable television.

CEGS. Army Corps of Engineers Guide Specification.

CFR. Code of Federal Regulations.

CMR. Communications riser.

CODEC. Coder/decoder.

CSU. Communications service unit.

DCI. Director of Central Intelligence.

DOD. Department of Defense.

DSS. Digital switching system.

DSU. Digital servicing unit.

EMI. Electromagnetic interference.

EMT. Electrical metallic tubing.

EPA. Environmental Protection Agency.

FDDI. Fiber distributed digital interface

HVAC. Heating, ventilating, and air conditioning.

LAN. Local area network.

LEC. Local exchange carrier.

LIU. Line interface unit.

MILDEP. Military department.

MILCON. Military construction.

MIL-HDBK. Military handbook.

MPOP. Main point of presence.

NAVFACENGCOM. Naval Facilities Engineering Command.

NEMA. National Electrical Manufacturers' Association.

NEXT. Near end cross talk.

NIC. Network interface card.

NFGS. Naval Facilities Guide Specification.

OEM. Original equipment manufacturer.

OFCR. Optical fiber conductive (strength member) riser.

OFNR. Optical fiber non-conductive (strength member) riser.

OSHA. Occupational Safety and Health Administration.

OTDR. Optical time domain reflectometer.

PC. Personal computer.

POP. Point of presence.

PVC. Polyvinyl chloride.

RCDD. Registered communication distribution designer.

REA. Rural Electrification Administration.

RF. Radio frequency.

RFI. Radio frequency interference.

STP.

TDR. Time domain reflectometer.

UL. Underwriters' Laboratories Inc.

UPS. Uninterruptible power supply.

UTP. Unshielded twisted pair.

WAN. Wide area network.

DEFINITIONS

Backbone. A facility comprised of pathway and cable which links two or more telecommunications closets, distribution terminals, entrance facilities, and equipment rooms either within or between buildings.

Bonding. The permanent joining of metallic parts to form a low loss electrically conductive path that will ensure electrical continuity and the capacity to safely conduct any current imposed on it. Commonly used to construct grounding systems.

Bridge tap. The multiple connection of the same cable pair at several distribution points.

Building entrance facility. The entrance to a building for both commercial and Government network service comprised of the grounding mechanism, pathway, and cable extending from the building entrance to the wall of the equipment room.

Buried cable. Cable which is plowed or trenched directly into the ground rather than run in duct.

Cable. An assembly of one or more metallic or fiber optic conductors within an enveloping sheath design to allow cable use singly or in groups.

Channel. An end-to-end transmission path between two points that includes the patch cord, station cord, and application specific equipment. It shall not exceed 100 m (328 ft.).

Conduit. A raceway of circular cross-section constructed of materials authorized by NFPA 70 and used to transport cables from point to point.

Cross-connect. A facility or function which provides for the termination and interconnection of cables.

Demarcation point. A point where ownership or operational control transfers. When pertaining to the transfer of operational control between the LEC and the Government, this point is referred to as the main point of presence (MPOP).

Distribution frame. A structure with terminations for connecting permanent cables in such a manner as to facilitate orderly cross-connection, documentation, and management.

Duct. Buried conduit.

Equipment room. A telecommunications closet, also functioning as the interface between inside and outside backbone cables, houses the primary switching and hubbing equipment and serves as the interface point between occupants of the building and outside networks serving the building. The point where the entrance facility terminates.

Ground. A conducting connection, whether intentional or accidental, between an object, usually an electrical circuit, and earth potential.

Horizontal cabling. The cable between and including the work station wall outlet and the horizontal cross-connect in the telecommunications closet.

Jumper. An assembly of twisted pairs without connectors, used to cross-connect voice grade cabling.

Link. Refer to horizontal cabling.

Media. Wire, cables, conductors, radio frequency, and infrared signals used for telecommunications connectivity.

Modular jack. A standard female telecommunications outlet used to provide a means of repeatedly connecting equipment to permanent cabling. A modular jack may contain either six or eight pins and may or may not be keyed.

Modular plug. A male telecommunications connector used to terminate a station cable or patch cord to a modular jack.

Multimode fiber optic cable. An optical fiber which allows more than one mode to propagate. The resultant intermodal dispersion causes signal deterioration which limits distance.

Optical fiber duplex connector. An EIA/TIA 568SC- compliant mated mechanical assembly designed to transfer power between two pairs of fiber optic cable.

Patch cord. The fiber optic or stranded copper cable used to connect the horizontal cabling and the backbone cabling to network equipment.

Patch panel. A cross-connect system of mateable connectors that facilitates administration.

Pathway. A facility for the placement and protection of telecommunications cables.

Pulling tension. The lateral force that may be applied to a cable without adversely affecting the characteristics of the cable.

Raceway. Any channel designed for holding wires or cables, e.g., conduit, EMT, sleeves, slots, underfloor duct, cellular floors, surface mounted channels, in-furniture utility channels, wireways, cable troughs, and busways.

Screen. A metallic foil or mesh that envelopes the pairs of a cable. Screening is used to reduce the effects of EMI and RFI.

Service entrance. The point of entry into the building by outside backbone cables through the exterior wall, concrete slab, or from conduit.

Shield. A metallic foil or mesh around the insulation of a conductor or pair of conductors. Shielding may also be applied beneath the overall cable jacket to provide strength, physical protection, and insulation from EMI and RFI.

Single-mode fiber optic cable. A fiber optic cable which is designed to allow only one mode to propagate. Distances achieved are a function of the quality of the light source.

Splice. The joining of conductors, generally from separate cable sheaths.

Star topology. A configuration that provides connectivity directly from the telecommunications outlet to the distribution device. A star can be physically or logically constructed.

Station cord. The fiber optic or stranded copper cable used to connect the horizontal cabling to the work station equipment.

Telecommunications. The transmission and reception of visual, audible, or recorded information by electromagnetic, radio, or optical means.

Telecommunications closet. An enclosed space for housing telecommunications equipment, cable terminations, and cross-connect cabling. The closet is the recognized location for performing the cross-connect between the backbone cables and the horizontal distribution cables.

Topology. The physical or logical configuration of a telecommunications network.

Underground cable. Cable run in ducts between manholes and handholes.

Workstation. The physical area and equipment used by the building occupant to interface the serving voice, data, and video networks.

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